KATHOLIEKE UNIVERSITEIT LEUVEN
FACULTEIT PSYCHOLOGIE EN PEDAGOGISCHE WETENSCHAPPEN
ONDERZOEKSGROEP VOOR GEZONDHEIDSPSYCHOLOGIE

OBSERVATIONAL LEARNING AND PAIN-RELATED FEAR

Proefschrift aangeboden tot het verkrijgen van de graad van

Doctor in de Psychologie door

Kim Helsen

Promotoren: Prof. Dr. Johan W. S. Vlaeyen & Prof. Dr. Liesbet Goubert

2013

OBSERVATIONAL LEARNING AND PAIN-RELATED FEAR

Kim Helsen

Promotoren:
Prof. Dr. Liesbet Goubert
Prof. Dr. Johan W. S. Vlaeyen

Proefschrift ingediend tot het behalen van de
academische graad van doctor in de Psychologie

2013

Kim Helsen

Observational learning and pain-related fear

Proefschrift aangeboden tot het verkrijgen van de graad van Doctor in de Psychologie, 2013
Promotoren: Prof. Dr. Liesbet Goubert & Prof. Dr. Johan W. S. Vlaeyen

---

Chronic pain is one of the major health problems in Western societies, with a prevalence of 19%. Not only does chronic pain account for enormous health care costs and lost working productivity, it also results in an extensive quality of life reduction. An important predictor in the development as well as the persistence of chronic pain problems is pain-related fear. The Fear-Avoidance Model (FAM) of chronic pain presents a plausible pathway by which people can get caught in a downward spiral of increasing avoidance, disability, and pain. Despite the accumulating research evidence supporting FAM in explaining the interference of pain in daily life, the different pathways to the development of pain-related fear have received scant attention in the pain literature so far.

The current project aimed at testing the possibility that pain-related fear can develop via an observational learning pathway, that is through observing others displaying pain behaviour during an encounter with a painful stimulus. For this purpose, a differential fear conditioning paradigm was used in several experimental studies with healthy participants. One of two formerly neutral stimuli (CS+ colour) was associated with painful facial expressions of models presented via video clips, while the other stimulus (CS- colour) was always paired with relaxed expressions of models. Observational learning was predicted to occur when the former stimulus acquired a threat value and elicited defensive responses by the participant, while the latter stimulus preserved its neutral valence. Second, we were interested in the extinction of observationally acquired pain-related fear after direct exposure to the conditioned stimulus. Third, we wanted to investigate the putative moderating effects of observers' characteristics in order to identify individuals who are at heightened risk of developing pain-related fear through observational learning. We expected pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy of the observer to facilitate observational learning processes. Results revealed that watching others in pain induced pain-related fear, and caused participants to expect higher pain unpleasantness, pain intensity, and perceived harmfulness regarding the CS+ compared to the CS- stimulus. These beliefs did, however, not always result in changes in behaviour or in changes in psychophysiological responses. Further research is needed to identify the conditions under which these changes do occur. When using a differential cold pressor task (CPT), pain-related fear persisted until the end of the experiment, whereas no differences between CS+ and CS- were found after direct exposure to coloured warm water tasks or cold metal bars. No unequivocal pattern was found across the experiments regarding the possible moderators.

The results of this project not only enhance our understanding of the acquisition of pain-related fear, it may also have implications for the development of prevention and cognitive-behavioural management strategies for patients with chronic pain.

Kim Helsen

Observationeel leren en pijngerelateerde vrees

Proefschrift aangeboden tot het verkrijgen van de graad van Doctor in de Psychologie, 2013
Promotoren: Prof. Dr. Liesbet Goubert & Prof. Dr. Johan W. S. Vlaeyen

---

Chronische pijn vormt een belangrijk maatschappelijk probleem in de Westerse wereld. Naar schatting heeft 19% van alle mensen last van pijn die langer dan 6 maanden aanhoudt. Chronische pijn vormt dan ook een belangrijke maatschappelijke gezondheidskost en leidt vaak tot een verminderde levenskwaliteit, die zich onder andere uit in psychologische problemen, arbeidsongeschiktheid, en afname van sociale contacten. Een belangrijke voorspeller voor zowel het ontstaan als in stand houden van pijnklachten is pijngerelateerde vrees. De introductie van het Vrees-Vermijdings model betekende een belangrijke doorbraak voor het onderzoek naar chronische pijn. Het model voorspelt dat catastrofale interpretaties van pijn leiden tot een neerwaartse spiraal van toenemende vermijding, beperkingen en (chronische) pijn. Verschillende factoren binnen dit model werden reeds empirisch getoetst, maar tot op heden is er nog te weinig aandacht besteed aan het ontstaan van pijngerelateerde vrees.

Het belangrijkste doel van dit doctoraatsproject was onderzoeken of deze vrees kan worden aangeleerd door observationele leerprocessen, aangezien mensen een groot deel van hun kennis verwerven via observatie van anderen. Concreet betekent dit dat vrees voor pijn niet door een eigen pijnlijke ervaring ontstaat, maar door observatie van het pijngedrag van andere personen die in contact komen met een pijnlijke stimulus. Om deze onderzoeksvraag te beantwoorden, werden in verschillende experimenten bij jongvolwassen participanten gebruik gemaakt van een differentieel conditioneringsparadigma. Een neutrale stimulus (CS+ kleur) werd gekoppeld aan faciale pijnexpressies van videomodellen, terwijl een tweede neutrale stimulus (CS- kleur) geassocieerd werd met neutrale gezichtsexpressies. Er is sprake van observationeel leren wanneer de eerste stimulus een dreigende betekenis verwerft, terwijl de tweede zijn neutrale betekenis blijft behouden. Ten tweede werd onderzocht of deze observationeel aangeleerde vrees voor pijn weer uitdooft na (herhaalde) aanbiedingen van de geconditioneerde stimuli in afwezigheid van de faciale expressies van de videomodellen. Ten derde wilden wij met dit onderzoek nagaan welke individuele karakteristieken van de observatoren een modererende rol hebben bij deze vorm van obervationeel leren van pijngerelateerde vrees. Wij verwachtten dat catastroferen over pijn, vrees voor pijn als karaktertrek, negatieve affectiviteit, onzekerheidsintolerantie en dispositionele empathie deze leerprocessen zouden faciliteren. Zoals verwacht toonden de resultaten aan dat het observeren van pijnlijke gezichtsexpressies van anderen resulteerde in een toename van pijngerelateerde vrees, en ervoor zorgde dat participanten meer onaangename en intense pijn en schadelijkheid verwachtten m.b.t. de CS+ in vergelijking met de CS- stimulus. Deze overtuigingen vertaalden zich echter niet altijd in veranderingen in gedrag of psychofysiologische responsen. Meer onderzoek is nodig om uit te klaren onder welke omstandigheden deze veranderingen zich voordoen. Wanneer gebruik gemaakt werd van een differentieel koud water paradigma was de pijngerelateerde vrees nog niet (volledig) uitgedoofd aan het einde van het experiment. Wanneer echter gebruik gemaakt werd van een paradigma met gekleurde warm water taken of koude staafjes werd er geen verschil gevonden in pijngerelateerde vrees na direct contact met de stimuli. Er werd geen eenduidig patroon gevonden wat betreft de mogelijke modererende effecten van de karakteristieken van de observator.

Dit project draagt niet enkel bij tot de opheldering van het ontstaan van pijngerelateerde vrees, maar biedt ook mogelijke aanknopingspunten voor het ontwikkelen van cognitief-gedragsmatige strategieën ter preventie en behandeling van chronische pijn.

Dreams require more than the power of one to make them real…

Daarom wil ik enkele personen bedanken die geholpen hebben bij de realisatie van dit project.

Liesbet en Johan,

ik had me geen betere promotoren kunnen wensen. Jullie waren fantastische inspiratiebronnen en ik heb dan ook mogen genieten van de expertise en feedback vanuit beide onderzoeksgroepen. Na elke samenkomst zat ik boordevol ideeën. Jullie motivatie, gedrevenheid en passie voor het onderzoek werkten aanstekelijk. Ik heb enorm veel bijgeleerd de afgelopen vier jaren en dat is voor een groot stuk jullie verdienste. Bedankt.

De leden van de begeleidingscommissie,

Bedankt voor jullie waardevolle suggesties en constructieve feedback tijdens onze jaarlijkse bijeenkomsten. Jullie hebben het project mee vorm gegeven en gewaakt over de rode draad tussen de verschillende studies. De vele ambitieuze ideeën werden mede dankzij jullie vertaald naar een haalbaar project.

De leden van de jury en de voorzitter,

Bedankt voor het kritisch nalezen van dit proefschrift.

Mijn collega's in Leuven,

Omer en Ilse, samen met Johan vormen jullie de drijvende kracht achter de onderzoeksgroep voor gezondheidspsychologie.

Erik, Stéphanie, Elyn, Ali en Kai, mijn bureaugenoten die mijn parcours vanop de eerste rij hebben gevolgd. Samen frustraties delen, maar ook delen in de vreugde wanneer er bijvoorbeeld een publicatie aanvaard werd.

Steven, Katleen, Elke, Meike, Thomas, Sibylle, Martien, Ann, Tom, Elena, Nele, Rena, Ruth, Mathias, Hassan, Marta, Joanna, Nathalie en Jonas. Bedankt voor de interessante labmeetings, de leuke retraites, de lunches bij de Thai en de congresuitstappen.

Jeroen, bedankt voor de leuke mac-momenten tijdens het monteren van de observatiefilmpjes en voor je hulp bij het programmeren van mijn experimenten.

Martine, Liesbet en An, bedankt voor de praktische ondersteuning.

Mijn collega's in Gent,

Annabelle, Line, Dimitri, Lies en Lore. Jullie zaten al met vijf personen samen in een bureau, maar hebben met plezier een plaatsje bijgemaakt voor mij gedurende de zes maanden dat ik in Gent werkte.

Geert, Stefaan, Tine, Emelien, Marieke, Valéry, Sophie, Lize, Annick, Nele, Lien, Wouter en Charlotte. Bedankt om mij op te nemen in jullie pijngroep, voor de feedback tijdens de meetings en voor de leuke etentjes.

Annick, Sylvie en Wouter, bedankt om me verder te helpen met alle praktische regelingen in Gent.

Tom Loeys, Eva Van den Bussche en Gerard van Breukelen,

Bedankt voor jullie hulp bij het opstellen van verschillende statistische modellen.

Marijke, Marjan, Rebecca, Katelijn, Evelyne, Annick, Karen en Nele,

Bedankt om te luisteren naar mijn doctoraats- en andere verhalen, voor de ontspannen afleiding tijdens onze ladies nights, etentjes en weekendjes. Bedankt om er te zijn, zowel op de leuke momenten, de zotte feestjes als op moeilijkere momenten. Jullie betekenen enorm veel voor mij. Marijke, je was de afgelopen jaren mijn carpoolmaatje en ik denk met veel plezier terug aan onze momenten in de feestmobiel, die het trotseren van de dagelijkse files een pak aangenamer gemaakt hebben. Katelijn, bedankt voor je creatieve inbreng en advies bij het ontwerpen van de cover van dit proefschrift.

Ma en pa,

Bedankt voor jullie onvoorwaardelijke steun en bemoedigende woorden. Jullie hebben me altijd vrij gelaten om uit te zoeken en te doen wat ik graag deed. Tom en Nele, ook al hebben we vroeger veel in elkaars haren gehangen, jullie waren een belangrijke steun voor mij en ik weet dat jullie trots op me zijn.

Table of contents

List of Tables

List of Figures

CHAPTER I:
General introduction

1 Pain

The International Association for the Study of Pain (IASP) defines pain as "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Merskey & Bogduk, 1994, p. 210). Pain comprises sensory-discriminative (intensity, location), affective-motivational (unpleasantness) as well as cognitive-evaluative (cognitions and beliefs) components (Melzack & Casey, 1968). Acute pain serves an important warning function in the recognition of danger or bodily threat. When pain persists beyond normal tissue healing time, which is stated at 3 months, it is said to be chronic (Merskey & Bogduk, 1994). Chronic pain is a common health problem, affecting biological, psychological, social, and economic well-being (Smith, et al., 2001), and can be described in terms of persistence, intensity, or disability (Elliott, Smith, Penny, Smith, & Chambers, 1999). Prevalence rates of persistent pain in the community vary from 7% to 64%, depending on the survey methodology and the studied sample (Hadjistavropoulos, et al., 2011; Perquin, et al., 2000). In Europe, 19% of the adult population suffers from chronic pain of moderate to severe intensity (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Although pain can be a major stressor for everyone throughout the whole lifespan (Crombie, Croft, Linton, LeResche, & Von Korff, 1999; Gagliese & Melzack, 1997; McAlpine & McGrath, 1999; Petersen, Brulin, & Bergstrom, 2006), it is more prevalent in women and at older ages (Hadjistavropoulos & Craig, 2004; Harstall & Ospina, 2003). Moreover, it is one of the most common reasons for seeking health care (Elliott, et al., 1999). Furthermore, chronic pain is often associated with other pathologies or problems, such as depression, anxiety, and insomnia (Ferini-Strambi, 2011; Pruimboom & van Dam, 2007).

2 Pain models throughout the years

In the following paragraphs, a non-exclusive historic overview of several important pain models is provided.

2.1 The Traditional Biomedical Model of Pain

In the Traditional Disease Model of René Descartes (1596 – 1650) a clear distinction was made between the mind and the body (Melzack & Wall, 1996). The mind was considered to be abstract and relating to feelings and thoughts, whereas the body was defined in terms of

fibres, skin, muscles, bones, brain and organs, working like a machine. Both were believed to function independently of each other. Descartes proposed that the mind communicated with the body through the pineal gland, located in the midbrain. According to the pain specificity theory, a unidirectional relationship existed between nociception or injury and pain perception (Descartes, 1664). More specifically, pain was said to be the result of threads pulling at the site of injury, which was then transmitted via nerve impulses to a pain centre in the brain (Mason, 2009). This theory is also known as 'the alarm bell' or 'push button' theory (Melzack, 1973). Descartes' views continued to influence pain research and treatment until the first half of the 20th century. However, this model failed to explain the persistence of chronic pain after the healing of an injury, when no nociceptive input was provided (Mason, 2009). Consequently, a broader model was needed, recognizing psychological processes in the study of pain.

2.2 The Gate Control Theory

In 1965, Melzack and Wall (1965) introduced the Gate control theory, which described how the brain is not a passive receiver of messages, but plays an active role in the perception of pain. The spinal cord comprises a neurological gate, located in the dorsal horn, which receives information from both the periphery and the brain. Nociceptive pain signals coming from small myelinated A-fibers are allowed to pass from the periphery through the gate, while signals from the large unmyelinated C-fibers are inhibited (afferent pathway). The subjective pain experience is further modulated by neural processes, such as higher cognitions and affective state, that descend from the brain (efferent pathway) (Hadjistavropoulos & Craig, 2004). The Gate control theory recognized the importance of emotional and motivational factors in the understanding of pain, providing the basis for the development of several biopsychosocial models.

2.3 Biopsychosocial pain models

Biopsychosocial models acknowledge that illness is caused by a multitude of factors, and not by a single causal pathology as believed in the traditional biomedical model (Engel, 1977; Melzack, 1973). Hence, they are able to capture the full scope of pain, being an interaction between biological (e.g., tissue damage), psychological (e.g., cognitions, behaviour and affect), and social factors (e.g., the cultural context) (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). An example of an influential biopsychosocial model is Loeser's model of pain (Loeser, 1982), describing different pain dimensions presented as concentric circles

with nociception at the centre spreading towards pain, suffering, and pain behaviour in the outer circle. For each transition to a subsequent level, certain thresholds have to be passed.

The primacy of affect in human pain experiences is central to many modern pain theories. The recognition of the importance of the reciprocal relationship between negative emotions such as fear or anxiety, and an individual's pain experience has led to the development of the Fear-Avoidance Model (FAM) of chronic pain (Lethem, Slade, Troup, & Bentley, 1983; Vlaeyen, Kole-Snijders, Boeren, & van Eek, 1995; Vlaeyen & Linton, 2000), in which two extreme responses to pain are described, namely confrontation and avoidance. The former is expected to lead to a reduction of pain over time, whereas the latter provides a possible pathway by which people can get trapped into a downward spiral of increasing pain and disability. FAM comprises affective (fear and anxiety), cognitive (pain catastrophizing and beliefs about harmfulness of painful stimuli), and behavioural (confrontation and avoidance) factors (see *Figure 1*). An important psychological factor in the development as well as the maintenance of chronic pain problems is pain-related fear (Leeuw, et al., 2007; Vlaeyen & Linton, 2012), which is scrutinized in the next paragraph.

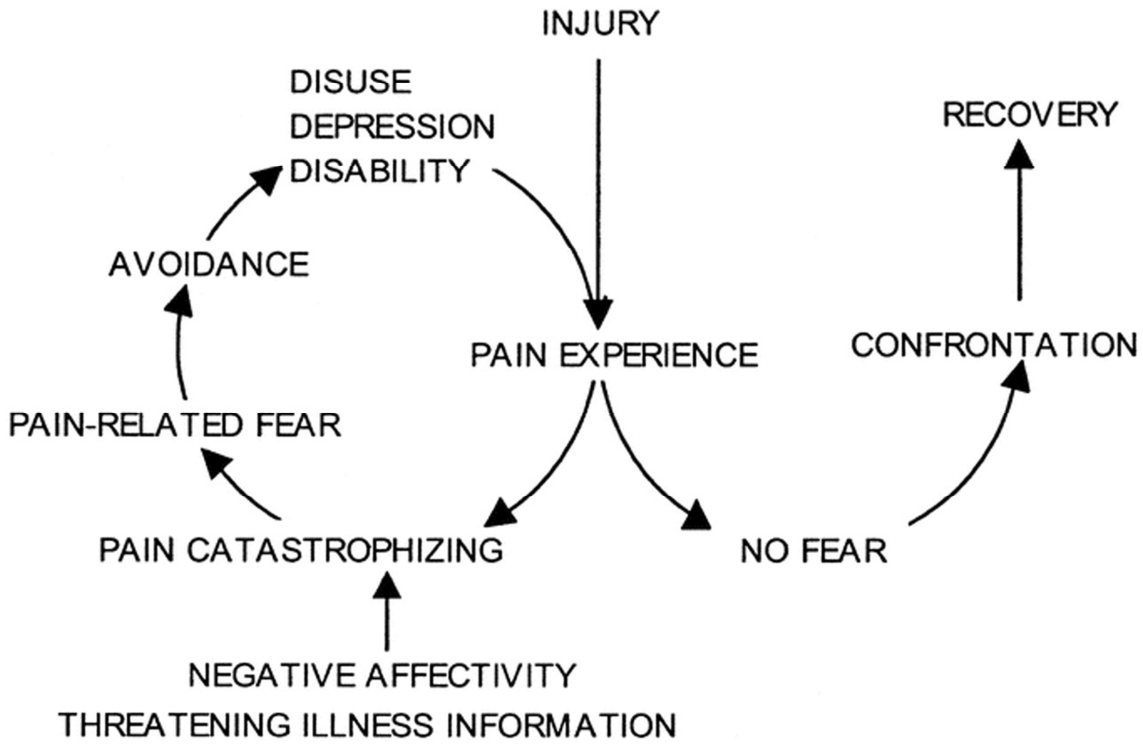


Figure 1. The fear-avoidance model of chronic pain. From Fear-avoidance and its consequences in chronic musculoskeletal pain: A state of the art, by Vlaeyen and Linton, 2000. Reprinted with permission.

3 Pain-related fear

Although fear and anxiety are often interchangeably used concepts, a considerable distinction can be made. While fear is the emotional expression in response to a specific, threatening event in the present, anxiety is a more general emotional state occurring in the anticipation of a possible threat in the future, hence containing more uncertainty (Helsen, Leeuw, & Vlaeyen, 2013). Consequently, fear is associated with defensive fight-or-flight behaviours, whereas anxiety motivates individuals to engage in preventive behaviours, such as avoidance (Vlaeyen, Morley, Linton, Boersma, & de Jong, 2012).

Pain-related fear, being one of the core concepts in the fear-avoidance model (see *Figure 1*) (Leeuw, et al., 2007; Vlaeyen & Linton, 2012), is an (often excessive) fear, that arises in the presence or the anticipation of a pain-eliciting situation (Kori, Miller, & Todd, 1990). The exact content of this fear may vary. Some individuals fear current or anticipated pain, while others might fear physical activity and consequent harm. This latter type of fear is also referred to as kinesiophobia or fear of movement/(re)injury (Lundberg, Larsson, Östlund, & Styf, 2006). Pain-related fear occurs in pain-free individuals as well as in persons suffering from different pain conditions, being a risk factor for both acute and chronic pain problems (Buer & Linton, 2002; Buitenhuis, Jaspers, & Fidler, 2006; de Jong, et al., 2005; Linton, Buer, Vlaeyen, & Hellsing, 2000; Picavet, Vlaeyen, & Schouten, 2002). It is shown to be associated with pain catastrophizing, hypervigilance for pain-related stimuli, escape and avoidance behaviours, increased pain intensity, decreased physical activities, and distress (Burns, Mullen, Higdon, Wei, & Lansky, 2000; Eccleston & Crombez, 1999; Leeuw, et al., 2007; van den Hout, Vlaeyen, Houben, Soeters, & Peters, 2001; Vlaeyen, et al., 1995).

4 Assessment tools for pain-related fear

Tailoring pain treatment to individual patient characteristics might be a useful strategy in pain management programs (De Peuter, de Jong, Crombez, & Vlaeyen, 2009). As pain-related fear appears pivotal in the inception as well as the maintenance of pain problems, screening patients in acute pain situations to identify the individuals with high pain-related fear might be a cost-effective strategy, since these individuals might benefit most from treatment targeting pain-related fear. Previous research has also indicated that pain-related fear reduction in an early stage of low back pain increases participation in physical activity despite the pain (Swinkels-Meewisse, et al., 2006). Several ways of assessing pain-related fear are described.

4.1 Questionnaires

Pain-related fear can be assessed using questionnaires such as the Tampa Scale for Kinesiophobia (TSK, Miller, Kori, & Todd, 1991; Vlaeyen, et al., 1995), the Fear-Avoidance Beliefs Questionnaire (FABQ, Swinkels-Meewisse, Swinkels, Verbeek, & Vlaeyen, 2003; Waddell, Newton, Henderson, Somerville, & Main, 1993), the Pain Anxiety Symptoms Scale (PASS, McCracken, Zayfert, & Gross, 1992; Roelofs, et al., 2004), or the Fear of Pain Questionnaire (FPQ, McNeil & Rainwater, 1998; Roelofs, Peters, Deutz, Spijker, & Vlaeyen, 2005). Questionnaires can be used as an initial screening tool and as an outcome measure throughout pain treatment.

In our studies, the Fear of Pain Questionnaire was used, because it has been frequently used in healthy samples, and it is clearly based on an underlying conceptual model (Lethem, et al., 1983). The FPQ comprises 31 items describing specific painful situations, as fear is assumed to be specific to particular stimuli and contexts (McNeil & Rainwater, 1998). Participants were asked to report on a 5-point scale (A = *no fear at all*; E = *extremely fearful*) the degree of fear they anticipated to experience regarding the pain described in each situation. Higher scores denote higher trait fear of pain. Three subscales (Severe pain, Minor pain, and Medical pain) can be distinguished, but often only the sum score is used (range 31-155). Previous studies have shown good reliability and validity of the FPQ in both clinical and non-clinical populations (McNeil & Rainwater, 1998; Osman, Breitenstein, Barrios, Guttierrez, & Kopper, 2002; Sperry-Clark, McNeil, & Ciano-Federoff, 1999).

4.2 Clinical interview

Even though questionnaires are a good screening or outcome instrument, they do not reveal details about the exact nature of an individual's fear experiences regarding pain. Accordingly, a clinical interview provides further information about the nature of pain-related fear, its onset, consequences regarding the persistence of pain, and its implications on daily life activities. Patients themselves often do not experience their problem as involving fear. They cannot do certain activities, not because they are scared, but because it causes pain, possibly leading to (re)injury. When exploring problems or providing psycho-education, it is important that the therapist speaks the same language as the patient. As such, problems might be investigated in terms of putative harm, rather than fear. Moreover, a harmfulness hierarchy of movements can be established, ranking movements in terms of gradually increasing harmfulness. Often the Photograph Series of Daily Activities (PHODA) is used to create such a hierarchy (Kugler, Wijn, Geilen, de Jong, & Vlaeyen, 1999). The PHODA pictures present

daily activities in which the back, neck, and limbs are used (e.g., working in the garden, cleaning the house). During exposure treatment, these pain-related movements are performed consecutively, starting with the movement that is perceived as least harmful. Throughout pain treatment, patients progressively become aware of different psychological aspects of their pain problem, reconceptualizing the problem using terms such as catastrophizing, avoidance behaviours, etc.

5 The development of fear in general

Before scrutinizing the observational learning pathway in the origin of pain-related fear, we should first take a look at the different pathways in the development of fear in general. Fear is an evolutionary important emotion in response to different types of threats, leading to escape and avoidance behaviours (Mineka & Öhman, 2002). Lang (1968) proposed that fear is best considered a latent construct that can be observed through at least three components: (1) self-reported beliefs and cognitions, (2) behavioural avoidance, and (3) psychophysiological responses. These components are not necessarily highly correlated. Fear conditioning can take place at different levels: The automatic associative level (emotional level), which involves mediation of the amygdala, and the non-automatic cognitive contingency level, in which the hippocampus is activated and participants are aware of the contingency between the conditioned stimuli (Mineka & Öhman, 2002; Tabbert, et al., 2011). If fear-relevant stimuli, such as snakes, are used in a conditioning procedure, usually both levels are independently addressed, while using fear-irrelevant stimuli, such as flowers, leads to activation of only the cognitive level. Accordingly, different types of measures (questionnaires, behavioural tests, skin conductance, …) can be used to investigate fear responses.

Fear can develop after the non-automatic formation and evaluation of propositions about relations between stimuli or events (De Houwer, 2009; Mitchell, De Houwer, & Lovibond, 2009), e.g., stimulus A *causes* stimulus B. Two important fear learning procedures are classical (respondent or Pavlovian) and operant (instrumental or Skinnerian) conditioning. Classical conditioning (Pavlov & Anrep, 1927) is a form of associative learning in which a relation between two types of stimuli is learned. When a formerly neutral stimulus (CS, conditioned stimulus) is functionally associated with an aversive stimulus such as pain (US, unconditioned stimulus), it acquires motivational qualities, possibly resulting in fear (CR, conditioned response). In operant conditioning (Skinner, 1948; Thorndike, 1927), the likelihood of instrumental behaviour increases or decreases as a result of its consequences

(e.g., Fordyce, Shelton, & Dundore, 1982). A paradigm that is often used in fear learning is differential conditioning. One stimulus (CS+, aversively conditioned stimulus) is associated with an aversive stimulus (US), while another similar stimulus (CS-, neutrally conditioned stimulus) is not. The control stimulus (CS-) is presented as frequently and under the same conditions as the aversively conditioned stimulus (CS+), representing safety versus fear learning, respectively (Otto, et al., 2007). Differential conditioning paradigms can be used in classical as well as in operant conditioning procedures. Furthermore, fear responses can be acquired through different sources of information. Three learning pathways have been proposed in the literature: Direct experience, verbal instruction, and observation (King, Gullone, & Ollendick, 1998; Mineka & Sutton, 2006).

5.1 Direct experience

Fear can develop after direct contact with a stimulus. After a traumatic experience, someone can develop fear with regard to that particular object or situation (Rachman, 1991). One of the first examples of direct conditioning is the case study of Little Albert (Watson & Rayner, 1920). A 9-month old baby did not show initial fear when exposed to a white laboratory rat. However, when a loud aversive noise was presented every time the rat was touched, little Albert started to show fear responses. Afterwards, when the rat was presented alone, little Albert showed significant distress and tried to move away from the rat. The fear even generalized to other white fuzzy animals such as rabbits. Direct aversive experiences may contribute to the onset of several fear and anxiety disorders (Britton, Lissek, Grillon, Norcross, & Pine, 2011; Lissek, et al., 2005; Mineka & Oehlberg, 2008). Regarding panic disorder, an initial panic attack (US) might become associated with particular internal (e.g., heart palpitations) or external (e.g., a specific room) cues (CS). Thereupon, the formerly neutral cue might start to elicit subsequent panic attacks (CR) (Bouton, Mineka, & Barlow, 2001). Similarly, in post-traumatic stress disorder (PTSD), re-experiencing PTSD symptoms after the appearance of an unpredictable and uncontrollable traumatic event (US), can be seen as a conditioned emotional response (CR) prompted by reminder cues that act as conditioned stimuli (CS) (Bouton, et al., 2001). In the context of pain, Meulders et al. (2011; 2012) were able to induce fear of movement in healthy participants using a voluntary joystick movement paradigm. When participants moved the joystick to a particular direction (CS+), they were given painful stimulation (US), while no such stimulation was given when they moved the joystick in the opposite direction (CS-). After several trials, the participants responded

fearfully (CR) when moving in the painful direction as compared to moving in the non-painful direction (Meulders, et al., 2011).

5.2 Verbal instructions

A second way of obtaining information about the association between two stimuli is through verbal instructions (Field, Argyris, & Knowles, 2001; Muris, Bodden, Merckelbach, Ollendick, & King, 2003; Olsson & Phelps, 2007). Negative information increases fear responses, while positive information might decrease fear (Muris, et al., 2003; Muris, Huijding, Mayer, van As, & van Alem, 2010; Vlaeyen, et al., 2009). Effects have been found in cognitive, behavioural, and psychophysiological response systems, and persist up to 6 months (Muris & Field, 2010), demonstrating that this learning pathway might be at the basis of many childhood fears and phobias (Rachman, 1977). Similar findings have been reported in the pain field. For example, when subjects were told that immersing a hand in a cold water tank might result in the tangling sensations that are a sign of frostbite, the task was reported as more threatening as compared to immersion in water with exactly the same temperature without such information (Vlaeyen, et al., 2009).

5.3 Observational learning

Observational learning, also referred to as vicarious learning, modelling, or social learning, is the ability to learn about the relationship between stimuli without direct experience of aversive or appetitive stimuli, but through observation of the behaviour of others when in contact with these stimuli (Bandura, 1965). The first observational learning studies mainly concerned transmissions of attitudes and behaviours in social psychology. One well-known demonstration of observational learning is the Bobo doll experiment (Bandura, Ross, & Ross, 1961), in which children engaged in more aggressive behaviour towards a doll after witnessing an adult playing violently with that doll. Despite several methodological and ethical critiques (Ferguson, 2010; Wortman & Loftus, 1992), this experiment inspired many other researchers to investigate observational learning processes, for instance in the fear learning context. Testing observational learning in the area of pain is the subject of this thesis and will be elaborated on later (see *6 Observational learning in the context of pain*).

5.3.1 Observational fear learning in adults

Berger (1962) was one of the first to experimentally investigate vicarious instigation in adults, which occurred when an observer inferred an individual's unconditioned emotional response (UR) from the situational context. Participants showed increased skin conductance responses (SCR) while observing a confederate being shocked after a buzzer sound. The

reaction increased when the confederate displayed overt pain behaviour in response to the shock (sharp arm movement). SCR was still enlarged when the buzzer was presented alone afterwards, providing evidence for the learned association between the buzzer (CS) and the shock (model's US). To increase clinical relevance, Hygge and Öhman (1978) conducted a study in which participants observed a confederate who was said to show increased SCR concerning a particular type of picture (model's US) for which a mocked phobia was reported by this confederate. For pictures (CS+) that were paired with this type of fear alleged stimulus, amplified SCR was detected in the observers, which was not the case for pictures that were not paired with this US (CS-). If the pictures were fear-irrelevant, SCR easily diminished when presented without the US picture, whereas augmented SCR concerning fear-relevant pictures did not extinguish, even though the model's US was not threatening for the observing participant. The findings of this study suggest that participants are reacting to the model's unconditioned response, rather than to the model's US.

5.3.2 Observational fear learning in monkeys

Until the 1980s, fear research in human participants mainly investigated autonomic responses, which are not always highly correlated with other fear components (Lang, 1968). Furthermore, these studies often involved the use of arbitrarily chosen neutral conditioned stimuli. However, from an evolutionary perspective, certain stimuli that form a threat for survival, such as snakes or spiders, are known to evoke more intense and persistent fear responses (Mineka, Davidson, Cook, & Keir, 1984). Using these types of stimuli might also increase ecological validity in the examination of specific fears and phobias. Consequently, Mineka, Cook and colleagues (1985; 1984) developed an observational conditioning paradigm for rhesus monkeys. Non-fearful laboratory-reared monkeys acquired snake fear after observing their wild-reared parent or an unrelated monkey acting fearful in the presence of a snake or snakelike toy. This fear led to persistent avoidance behaviour and distress. Afterwards, the observer monkeys acted as a model for other laboratory-reared monkeys, provoking fear, albeit less intense. In order to find out whether the observer was reacting to the model's US (snake = observer's CS), the model's UR, or both, Mineka and Cook (1993) conducted an experiment in which half of the monkeys were not able to see which stimulus the model was responding to. All monkeys reacted with similar levels of distress, suggesting that they were responding to the model's UR, not the snake.

5.3.3 Observational fear learning in children

Many fears and phobias originate in early childhood. Because children have limited prior experiences compared to adults, they are especially susceptible to observational learning influences. Most of the experimental studies on observational learning in children concern maternal modelling. Infants and toddlers (12-20 months) show more fear emotions and avoidance behaviour when confronted with a toy that was previously paired with fearful facial and verbal expressions of their mothers (Dubi, Rapee, Emerton, & Schniering, 2008; Gerull & Rapee, 2002; Mumme, Fernald, & Herrera, 1996). These findings apply to fear-relevant (snakes and spiders) as well as fear-irrelevant toys (flowers and mushrooms) (Dubi, et al., 2008; Gerull & Rapee, 2002). Toddler's fear expressions and avoidance behaviours were still present after 10 minutes in the study of Gerull and Rapee (2002), but had extinguished after 10 minutes in the experiment of Dubi and colleagues (2008). Egliston and Rapee (2007) demonstrated that prior positive maternal modelling protected toddlers (12-21 months) from developing fear during a negative observational learning procedure in which a stranger (the experimenter) displayed fear and disgust regarding a spider or snake toy. Positive emotional responses and approach behaviours with respect to the toy were still present after 20 minutes. Mere exposure to the toy before the conditioning procedure could not prevent the generation of fear. Research in primary school children showed that fear beliefs and avoidance behaviours regarding a novel animal can arise as a result of pairing a picture of this animal with a picture of a scared face, with fear beliefs persisting up to 3 months (Askew & Field, 2007). Broeren and colleagues (2011) compared positive and negative peer modelling using an observation video in which peers interacted with a novel animal (guinea pig). Concerning the positive modelling condition, children reported less fear beliefs and displayed less avoidance behaviour regarding both the modelled and a non-modelled animal. Following negative modelling, fear beliefs increased for the modelled, but not the non-modelled animal, while avoidance tendencies did not change for the modelled animal, but decreased for the non-modelled animal.

To summarize, experimental evidence was found for the existence of the three different learning pathways in the generation of fear. Retrospective clinical studies corroborate these findings (King, 2005; King, et al., 1998; Merckelbach, Muris, & Schouten, 1996; Ollendick & King, 1991). In the following paragraphs, the observational learning pathway is further examined in the area of pain.

6 Observational learning in the context of pain

Observational learning is important in shaping an individual's pain response and experience. Modern learning theories conceptualize observational learning as behavioural changes as a consequence of observing regularities in one's environment (De Houwer, 2009; Goubert, Vlaeyen, Crombez, & Craig, 2011). Behavioural responses may reflect automatic or reflexive processes, neuronal activity, or behaviours following deliberate control. In the context of pain, studies have mainly focused on the influence of modelling on pain intensity, pain threshold, or pain tolerance. For example, Craig and Weiss (1971) examined the impact of pain tolerant and intolerant models on students' verbal pain reports induced by electrical pain stimulation. A significant impact was found on both pain expressions and willingness to accept pain stimuli of increased intensity. Observing tolerant models also led to a reduction in subjective distress (Craig & PrKachin, 1978) Furthermore, correlations were found between juvenile arthritis patients and their parents with regard to pain intensity as well as pain tolerance (Thastum, Zachariae, Bjerring, & Herlin, 1997). However, these studies about vicarious learning and pain did not provide information about the development of *fear* of pain. In the following paragraphs, an overview is presented of several experimental and clinical studies examining observational learning of pain-related fear.

6.1 Observational learning of pain-related fear in animals

Social transmission of information about possible threats is essential for the survival of a species. Observing a conspecific receiving electric shocks causes freezing behaviour in rodents (Bruchey, Jones, & Monfils, 2010; Church, 1959). Fear responses persist when the cue (e.g., a tone) that predicted the electric shock for the model was presented alone afterwards, showing that the association between the tone (CS) and the electric stimulus (US) had been learned (Chen, Panksepp, & Lahvis, 2009). Moreover, fear learning effects tend to be larger when the model rodent is a sibling, mating partner, or cage-mate (Bruchey, et al., 2010; Jeon, et al., 2010). Accordingly, fear of pain can be transmitted through observation in rodents.

6.2 Observational learning of pain-related fear in children

Children's pain-related fear can be altered after witnessing their mothers performing a cold pressor task in which the mothers exaggerate their pain (Goodman & McGrath, 2003). Pain threshold was lower in children who observed (exaggerated) pain compared to a control condition, although no differences were found regarding children's subjective pain intensity

ratings or painful facial expressions. Clinical research demonstrated an increased risk of pain and disability in children of chronic pain patients (Goodman, McGrath, & Forward, 1997; Mikael & von Baeyer, 1990). Moreover, if a mother showed more pain-related fear before the needle injection of her child, the infant looked more at the mother's face during the injection while showing more distress and facial pain expressions (Horton & Riddell, 2010). Hence, it may be stated that evidence has been found for an observational learning pathway for pain-related fear in children.

6.3 Observational learning of pain-related fear in adults

A few studies have investigated the effects of observation of pain owing to an electrocutaneous stimulus in others on observers' autonomic responses, using a differential conditioning paradigm (Olsson, Nearing, & Phelps, 2007; Olsson & Phelps, 2004; Vaughan & Lanzetta, 1980). During the observation phase, one stimulus (CS+: a coloured square, an angry face picture, or a word pair, respectively), was associated with a model receiving a shock, whereas a similar stimulus (CS-) was not. Participants showed larger skin conductance responses (SCR) when observing the CS+ stimulus compared to the CS- stimulus. During the test phase, when the CS+ was presented without the model being shocked, differential effects were found to be resistant to extinction (Olsson, et al., 2007; Olsson & Phelps, 2004). Results were similar when heart rate and self-reported pain intensity were measured (Colloca & Benedetti, 2009). Although some adult studies have focused on observational learning of pain-related fear, the evidence is meagre. For instance, no research has been done to investigate the effect of observation on pain-related fear beliefs or behaviour. Therefore, the aim of this dissertation was to examine the effect of socially transmitted pain-related fear on different fear components (beliefs, behaviour, and autonomic responses).

7 Reduction of pain-related fear after observational learning

The increasing evidence that pain-related fear has an important role in the development as well as the persistence of chronic pain problems has led to pain management strategies that focus on targeting this fear. Experimental evidence on the reduction of pain-related fear can be found in the extinction literature. Extinction may occur if a conditioned fear response (CR) diminishes or extinguishes after repeated exposure to the CS without presentation of the US. With regard to human pain research, observers showed increased skin conductance responses (SCR) when a buzzer (CS) that previously predicted presentation of a painful shock (US) to a model, was presented alone afterwards (Berger, 1962). When the

presentation of the buzzer was not followed by an actual shock, SCR easily diminished. However, in other studies, also using an electrocutaneous stimulus as the model's unconditioned stimulus (US), differential conditioning effects were found to be resistant to extinction (Colloca & Benedetti, 2009; Olsson, et al., 2007; Olsson & Phelps, 2004).

In clinical practice, several treatments are aimed at decreasing levels of pain-related fear, irrespective of the learning pathway that has led to the acquisition of pain-related fear. The most common treatments are graded exposure in vivo, graded activity, acceptance and commitment therapy (ACT), and a mixture of different cognitive behavioural techniques such as relaxation training, assertiveness training, and cognitive reappraisal (Bailey, Carleton, Vlaeyen, & Asmundson, 2010; McCracken & Turk, 2002). In chronic pain patients, exposure in vivo therapy and ACT are shown to be the most effective in changing pain-related fear beliefs (Bailey, et al., 2010; Lohnberg, 2007; Vlaeyen, de Jong, Geilen, Heuts, & van Breukelen, 2001; Vlaeyen, et al., 2012). Graded exposure in vivo was developed so that patients can experience that their anticipated fear of pain and harmfulness is unfounded (Leeuw, Vlaeyen, de Jong, & Goossens, 2006; Vlaeyen, de Jong, Sieben, & Crombez, 2002). Treatment starts by giving the patient psycho-education concerning the fear-avoidance model, the links between its different components, and possible consequences with respect to the maintenance of their pain problem. Next, patients are exposed to movements that they used to avoid prior to treatment, gradually increasing perceived harmfulness of the movements. In order to improve beneficial outcome and to prevent relapse, participants are asked to repeat these exercises in as many situations and contexts as possible. In ACT, patients learn to accept the presence of their pain, and be aware of it without feeling the urge to control it (Bailey, et al., 2010). Hence, ACT also comprises an exposure component. Furthermore, reduction of pain-related fear is shown to encourage participation in daily life activities, decreasing affective distress, disability, and pain (De Peuter, et al., 2009; Turk & Wilson, 2010; Woods & Asmundson, 2008). The purpose of clinical treatments targeting pain-related fear is to disconfirm expectancies regarding for instance a feared movement by letting the individual experience directly that no harm is followed by the performance of the movement, whereas in most experimental research, participants do not have direct experience with the characteristics of an actual shock. Direct comparison of existing experimental literature on extinction of pain-related fear and exposure therapy is therefore difficult. By contrast, in the experimental studies that were conducted as part of this dissertation, the feared stimulus was directly presented to participants after an observational learning procedure.

8 Project aims

Although the role of fear in the development of chronic pain problems has received considerable attention, very few studies examined how pain-related fear might develop. Three possible pathways have been proposed in the literature: Direct experience, verbal instruction, and observation (Rachman, 1977). In this dissertation we have focused on the observational learning pathway in the development of pain-related fear. While previous studies have focused upon observational learning of the psychophysiological component of pain-related fear, the current project is aimed at testing the possibility that pain-related fear can develop via an observational learning pathway, including measures of pain expectancy, avoidance behaviour, and psychophysiological responding. A differential fear conditioning paradigm was used in several experimental studies with healthy participants. One of two formerly neutral stimuli was associated with painful facial expressions of a video model, while the other stimulus was always paired with a relaxed expression. Observational learning occurs when the former stimulus acquires a threat value and elicits defensive responses by the participant, while the latter stimulus preserves its neutral valence. Second, we are interested in the extinction of observationally acquired pain-related fear after (repeated) exposure to the conditioned stimulus. Third, we want to investigate the putative moderating effects of observers' characteristics in order to identify individuals who are at risk of developing pain-related fear through observation. The moderating effects of pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy of the observer were examined.

In chapter II, III, and IV of this dissertation, several experimental studies are described, using differential conditioning paradigms involving cold pressor tasks, cold metal bars, and warm water tasks, respectively. Chapter V elaborates on intolerance of uncertainty, which is a putative facilitating observers' characteristic in observational learning processes. A confirmatory factor analysis of the Intolerance of Uncertainty Scale (IUS) was conducted to determine the best factor structure concerning the full and short version of the IUS.

The results of this project not only enhance our understanding of the acquisition of pain-related fear, it may also have implications for the development of prevention and treatment strategies in the area of chronic pain.

CHAPTER II:

Observational Learning and Pain-related Fear:

An Experimental Study with Coloured Cold Pressor Tasks

Abstract

The primary aim of the current study was to experimentally test whether pain-related fear can be acquired through observational learning, whether extinction occurs after actual exposure to the aversive stimulus, and whether pain-related fear was associated with increased pain ratings. During an observation phase, female volunteers watched a video showing models performing cold pressor tasks (CPT), of which the colour served as a conditioned stimulus (CS). In a differential fear conditioning paradigm, each of two colours was either paired with models' painful (CS+) or neutral (CS-) facial expressions. Exposure consisted of participants performing CPT of both colours (10°C). Self-reported fear of pain, and expected pain ratings were obtained after the observation period, while actual pain and avoidance measures were obtained during and after exposure. Results showed that after observing another person performing the CPT associated with the painful faces, subjects reported more fear of pain and expected more intense and unpleasant pain as compared to the CPT associated with the neutral faces. This effect of observational learning on pain-related fear persisted until after exposure. During and after exposure no stimulus type effect for pain ratings was found. This study provides preliminary evidence for observational learning of pain-related fear in humans.

Perspective:

Fear of pain can be more disabling than pain itself, and is a risk factor for chronic pain. Knowledge about the acquisition of pain-related fear may help developing novel pain management programs. This study is one of the first to demonstrate the effects of observational learning on pain-related fear.

Key words: Observational learning, pain-related fear, facial expressions

Helsen, K., Goubert, L., Peters, M. L., & Vlaeyen, J. W. S. (2011). Observational learning and pain-related fear: An experimental study with colored cold pressor tasks. The Journal of Pain, 12, 1230-1239.

* investigation of possible differential moderation effects has been added to the version in this dissertation

1 Introduction

Modern psychological theories of pain emphasize the importance of negative emotions in the individual's experience and response to pain (Gatchel, et al., 2007; Staats, Hekmat, & Staats, 1996). In the last decades, researchers started focusing on the reciprocal relationship between pain and anxiety/fear. For instance, pain-related anxiety was found to amplify subjective pain experience, and to predict pain behaviour (Feldner & Hekmat, 2001; McCracken, Zayfert, & Gross, 1993). Likewise, Litt (1996) demonstrated that perceived or anticipated pain increases anxiety. A major breakthrough was the introduction of the Fear-Avoidance Model (FAM) of chronic pain, which presents a plausible pathway by which people get caught in a downward spiral of increasing avoidance, disability, and pain (Asmundson, Norton, & Norton, 1999; Hollander, et al., 2010; Leeuw, et al., 2007; Lethem, et al., 1983; Vlaeyen & Linton, 2000).

Although there is accumulating research evidence supporting FAM, there are some unresolved issues. To date, it remains unclear how exactly pain-related fear develops. Fear learning in general depends on the formation and evaluation of propositions between stimuli (Mitchell, et al., 2009). Propositions are statements about the way in which objects or events are related, e.g. stimulus A might *cause* stimulus B (De Houwer, 2009). In the literature, three pathways to acquire knowledge about these propositions have been proposed (King, et al., 1998; Mineka & Sutton, 2006). First, people can learn from direct experiences. After a traumatic experience, someone can develop a fear with regard to that particular object or situation (Rachman, 1991). Second, emotional information can be obtained through verbal instructions (Muris, et al., 2003; Olsson & Phelps, 2007). Negative information increases fear responses, while positive information might decrease fear. Third, fear can be learned indirectly through observing others in pain (Askew & Field, 2007; Askew & Field, 2008). Bandura (1986) defined this latter type of learning as *'changes in patterns of behaviour that are a consequence of observing others' behaviours'*.

In the context of pain, studies concerning observational learning have mainly focused on the influence of modelling on pain intensity, threshold, and tolerance (Craig & Weiss, 1971; Delgado, Olsson, & Phelps, 2006). However, literature on the effect of observational learning on *fear* of pain is scarce. Olsson et al. (2004) systematically investigated different pathways leading to pain-related fear. Comparisons between these learning types (operationalized by changes in skin conductance) revealed that observational and verbal fear learning can be as effective as aversive learning through first-hand experience.

Whereas the previous studies have mainly focused on autonomic responses and neural activity (Olsson, et al., 2007; Olsson & Phelps, 2004, 2007), the purpose of the current study is to examine whether observational learning of pain-related fear can lead to changes in fear beliefs and avoidance behaviour, and whether this fear of pain extinguishes after actual exposure. Additionally, observational learning effects on pain unpleasantness and pain intensity are investigated. Furthermore, putative moderating effects of the observer's characteristics are explored. To address these questions, a differential fear conditioning procedure was used in healthy young adults. Participants watched a video showing human models performing two coloured cold pressor tasks (CPT). In a counterbalanced set-up, one colour (CS+) was paired with painful facial expressions; the other colour (CS-) with neutral faces. We expected participants to report more fear, and to expect higher pain unpleasantness and higher pain intensity regarding the CPT associated with the painful faces after watching the video models (observation phase). The differences in reported fear and expectancies between the two tasks were hypothesized to extinguish after direct contact with the stimuli (exposure phase). Moreover, we examined the putative influence of pain catastrophizing, trait fear of pain, and negative affectivity on these observational learning effects.

2 Materials and Methods

2.1 Participants

Sixty-two healthy female undergraduate (psychology) students of the University of Leuven (Belgium) participated in this experiment, for which they received either a course credit or five Euros. Exclusion criteria were colour-blindness, diabetes, epilepsy, Reynaud's disease, recent arm fracture or wrist sprain prior to participating, earlier frostbite, hypertension, and chronic pain. Participants were asked not to consume any caffeine-containing or alcoholic drinks at least two hours before testing. None of the participants had ingested analgesic pain medication on the day of testing. The mean age of participants was 19.8 (SD = 1.8, range 18-24). All (but one Chinese) participants were Caucasian. They all signed the informed consent document, stating that they would be asked to immerse their hands in different coloured liquids at different temperatures for one minute each time, which was a harmless duration for the chosen temperatures. Nevertheless, participants were told that they could end participation at any time for any reason. Participants were randomly assigned to one of four conditions, depending on the colour of the CS+, and the order of the CPT. Eight participants (13%) were left-handed. Ethical approval was obtained through the Ethics

Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium).

2.2 Apparatus and materials

Two identical Plexiglas boxes (Julabo®) were used as cold pressor task (CPT) apparatus, containing an electric immersion cooler, type FT200, and a bath circulator, type ED-19A. Each immersion bath measured 18cm high, 27cm wide, and 39cm long. In contrast to previous CPT studies, in which water temperatures of 2 to 4°C are generally used to induce painful sensations, temperature in the current experiment was held constant at 10°C (± 0.03°C). This temperature was considered to produce a more ambiguous sensation, leaving room for cognitive reappraisal of the experience. In situations of uncertainty, individuals tend to extract information from the environment to disambiguate the situation. Consequently, we expect participants to use the information of the facial expressions seen in the video to affect the meaning of their own immersion experiences (Arntz & Claassens, 2004). The cold pressor apparatus was placed upon a trolley adjustable in height to provide comfortable access to the Plexiglas box. A registration button was placed on the bottom of each box to determine immersion latency and early withdrawal. A third box, type TW20 Julabo, was used for water at room temperature (20.5°C ± 0.5°C). Before each CPT, participants were requested to hold their hand in this box for 60 seconds to ensure they all started with a similar skin temperature.

Painful facial expressions were used as aversive unconditioned stimuli; neutral faces as neutral stimuli. Video material with human facial expressions from a previous CPT study at the Maastricht University (Netherlands) was used with participants' consent (Vlaeyen, et al., 2009). Facial expressions in that study were assessed by means of the Child Facial Coding System (CFCS) (Chambers, Cassidy, McGrath, Gilbert, & Craig, 1996), a coding system derived from the Facial Action Coding System (Ekman & Rosenberg, 1997), which can also be used in adults. Sixteen female participants – eight with the highest and eight with the lowest facial pain expression scores – were selected to create a video extract with a duration of 682 seconds. Models in this video were presented randomly with the restriction that a CS+ fragment always followed a CS- fragment. All video models were healthy females, both students and staff of the Maastricht University, performing a cold pressor task at 2°C. This temperature was cold enough to induce pain expressions. Mean age of the models was 31 years old for the CS+ condition fragments (median = 25.5, range 17-59), and 32 for the CS- fragments (median = 25.5, range 21-56). In each condition, there was one video model wearing glasses.

Ecoline, which is a safe and harmless colourant, was used to create two different CPT (Creall®; orange, 1371003; pink, 1371017). One colour (CS+) was associated with the painful facial expressions, while the other colour (CS-) was paired with the neutral facial expressions (counterbalanced).

Each trial began with a video fragment of a hand immersing a CPT with coloured water (orange vs. pink) appearing alone on the left side of the screen. After two seconds, a video extract of a model showing either a painful or a neutral facial expression, appeared on the right side of the screen and the coloured CPT started to fade away. Two versions were made of this video: one with the pink CPT and the other with the orange CPT associated with the painful facial expressions.

2.3 Measures

2.3.1 Self-reports regarding the CPT

After watching the video, as well as after each immersion, a list of single item numerical rating scales (NRS) was presented (Seminowicz & Davis, 2006; Van Damme, Crombez, Van Nieuwenborgh-De Wever, & Goubert, 2008; Vlaeyen, et al., 2009). Participants indicated the level of fear (0 = *not fearful at all*; 10 = *very fearful*), pain unpleasantness (-5 = *very unpleasant*; 5 = *very pleasant*), and pain intensity (0 = *not painful at all*; 10 = *very painful*) they expected to experience (observation phase) or actually experienced (exposure phase) with regard to both CPT. Pain unpleasantness scores were recoded afterwards (0 = *very pleasant;* 10 = *very unpleasant*). Experienced pain intensity during exposure was assessed using verbal pain ratings instead of NRS (Vlaeyen, et al., 2009). Participants reported their experienced pain intensity out loud every time a tone was presented (5s, 10s, 20s, 40s, and 60s during immersion; 20s, 40s, and 60s after immersion). A pain rating scale, ranging from 0 (*not painful at all*) to 10 (*extremely painful*), accompanied the tone on a computer screen as a guideline for participants. At the end of the experiment, self-reported hesitation to immerse their hand in both CPT was assessed using a NRS (0 = *not at all*; 10 = *very much*).

2.3.2 Avoidance behaviour

Time that elapsed between the appearance of the instruction on the computer screen ('you may now immerse your hand into the liquid') and pressing the registration button on the bottom of each coloured CPT was registered (with Affect 4.0, a Windows-based software package) (Spruyt, Clarysse, Vansteenwegen, Baeyens, & Hermans, 2010). This latency time

was considered a behavioural measure of avoidance tendency. At the end of the experiment, participants were asked which of the two coloured immersions they wanted to repeat if they had to choose one more immersion task and for which reason. Avoidance of the task that was associated with the painful facial expressions was considered an indicator for pain-related fear.

2.3.3 Pain Catastrophizing

The 13-item Pain Catastrophizing Scale (PCS) measures the frequency of catastrophizing thoughts and feelings people generally experience during painful situations (Sullivan, Bishop, & Pivik, 1995; Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002). Such experiences include headaches, tooth pain, joint, or muscle pain, and may be caused, for instance, by illness, injury, dental procedures, or surgery. Ratings were given on a 5-point Likert scale ranging from 0 *(not at all)* to 4 *(always)*. Examples of items include 'When I'm in pain, I feel I can't stand it anymore', 'When I'm in pain, I can't seem to keep it out of my mind', and 'When I'm in pain, I become afraid that the pain may get worse'. Although a three factor structure - with the subscales Rumination, Magnification, and Helplessness – has been reported, only the total PCS score was used in this experiment, with high scores representing high levels of pain catastrophizing. Psychometric analyses revealed good internal consistency (Cronbach's alpha = 0.90) and construct validity (Crombez, Vlaeyen, Heuts, & Lysens, 1999; Van Damme, et al., 2002).

2.3.4 Trait Fear of Pain

The Fear of Pain Questionnaire (FPQ) consists of 31 items describing painful experiences (McNeil & Rainwater, 1998; Roelofs, et al., 2005). Participants report the degree of fear they experienced when going through those kinds of pain. Answers were rated on a 5-point Likert scale (A = *no fear at all*; E = *extremely fearful*). The three-factor model of the FPQ consists of the subscales Severe pain, Minor pain, and Medical pain, but only the total score was used in our study. Internal consistency and test–retest stability of this questionnaire are good (Cronbach's alpha = 0.91), and validity has been supported in clinical as well as non-clinical samples (Osman, et al., 2002; Roelofs, et al., 2005; Sperry-Clark, et al., 1999).

2.3.5 Trait Negative Affectivity

Negative affectivity was measured by means of the Trait version of the Positive And Negative Affect Schedule (PANAS) (Peeters, Ponds, & Vermeeren, 1996; Watson, Clark, & Tellegen, 1988). This questionnaire consists of 20 adjectives describing positive and negative emotions. Participants were requested to rate the frequency by which they experienced those

feelings in daily life (*very little*; *very often*). The PANAS consists of two subscales, namely Positive affectivity and Negative affectivity, but only the latter one was of interest in this study. The sum of the ten negative adjective scores yielded the total score for Negative affectivity (PANAS-NA). Internal consistency of this subscale indicated good reliability (Cronbach's alpha = 0.88).

2.3.6 Contingency awareness

At the end of the experiment, participants were shown a picture of each of the two coloured CPT together with 16 pictures of the video models of the observation phase. Painful or neutral facial expressions of the models were clearly visible. Participants were asked to sort out these pictures into two piles, combining the models with the CPT used in the video.

2.4 Procedure

Participants were informed about the course of the experiment before signing informed consent. They were told that the study investigated responses to cold stimuli. Before the start of the experiment, participants completed the Pain Catastrophizing Scale (Van Damme, et al., 2002), the Fear of Pain Questionnaire (Roelofs, et al., 2005), and the Trait version of the Positive And Negative Affect Schedule (Peeters, et al., 1996).

The experiment consisted of three phases (see *Figure 2*). During the *observation phase*, the video of the 16 facial expressions of human models performing a CPT was shown on a computer screen. Afterwards, participants were asked to report pain-related fear, expected pain unpleasantness, and expected pain intensity related to their own performance on the upcoming CPT, without being aware of the total duration of the tasks. During the *exposure phase*, participants consecutively immersed one hand in the first CPT (e.g. CS+) and the other hand in the second CPT (e.g. CS-), for one minute each time, without watching the neutral and painful facial expressions. The order of the CPT was counterbalanced to control for carry-over effects. Both immersions were preceded by a one-minute room temperature immersion and followed by a recovery period, also lasting one minute. Temperature of the water was held constant at 10°C. During immersion, a tone was presented at five points in time. At those moments, participants verbally indicated the level of pain they experienced on an 11-point rating scale. After 60 seconds, the instruction to remove the hand from the coloured liquid appeared on the computer screen. During the *recovery phase* (one minute after each immersion), the same tone was presented and pain ratings were registered in order to examine the decline of participants' pain experience. After each CPT, participants were

instructed to report pain-related fear and pain unpleasantness, based on their current experience with both CPT. Once the two tasks were completed, self-reported hesitation was assessed and participants were asked which of the CPT they wanted to repeat if they had to choose one more immersion task and for which reason. Subsequently, contingency awareness was checked by means of pictures of the models from the video extracts. At the end of the study, all participants were invited for a debriefing where they were informed about the objectives and broader context of the experiment.

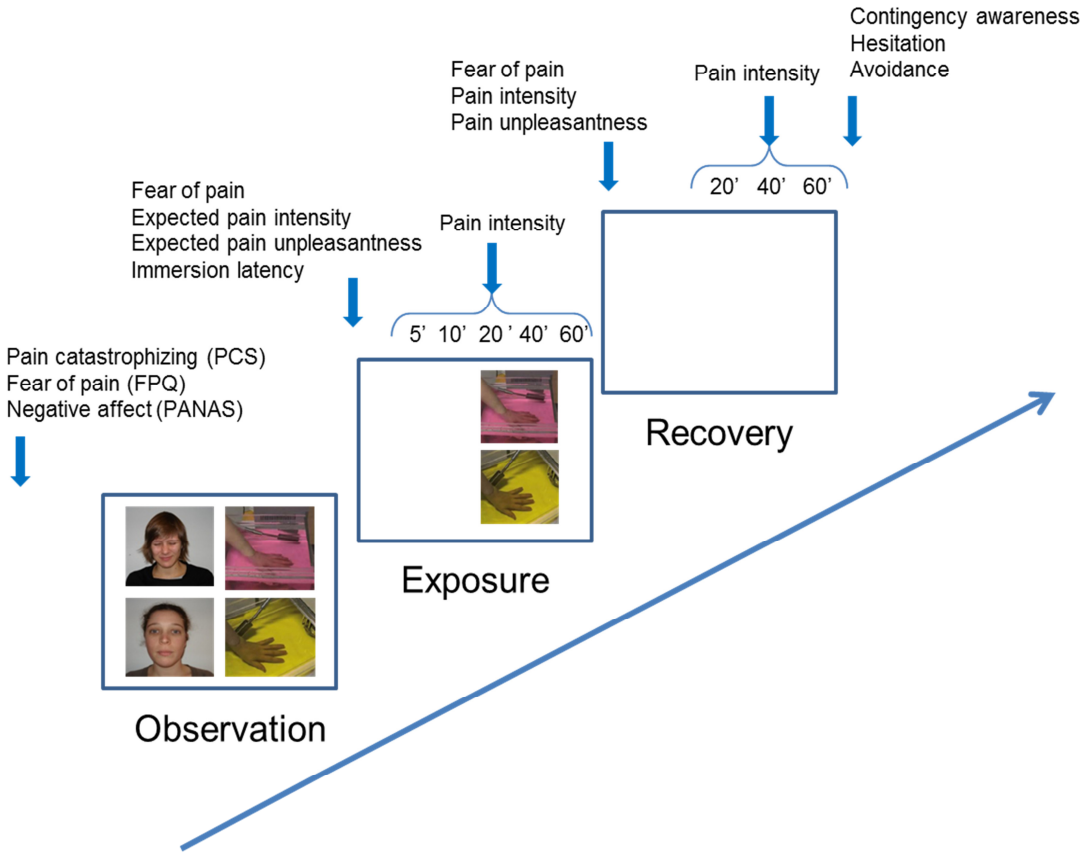


Figure 2. Graphical overview of the experimental procedure, with the measurements during the observation, exposure, and recovery phases. During the observation phase, one colour is associated with painful facial expressions of the video (top), while the other colour is paired with neutral expressions (bottom).

2.5 Statistical analyses

Repeated measures ANOVA, with stimulus type (CS+ versus CS-) as the within subject variable, was used to analyse indices of *pain-related fear*, both after observation and exposure. Similar analyses were conducted for *pain unpleasantness, expected pain intensity,* immersion latency, and self-reported hesitation. *Experienced pain intensity* was investigated

separately for exposure and recovery by means of repeated measures ANOVA with stimulus type and time as within subject variables. In order to investigate the influence of putative moderators, centered PCS, FPQ, and PANAS-NA scores were entered as covariates. Moderation was present if a significant statistical interaction was found between scores on the questionnaire and stimulus type. Regression analyses were conducted separately for both stimulus types to explore moderation effects. Subsequently, regression slopes were plotted. All analyses were conducted with an alpha ≤ 0.05, using SPSS 17.0. Where relevant, Greenhouse-Geisser estimates of sphericity were used to correct degrees of freedom whenever this sphericity assumption was violated (Mauchly's Test of Sphericity), resulting in the report of partial degrees of freedom.

3 Results

3.1 Sample characteristics

Participants' scores on the questionnaires are presented in Table 1. Mean scores were comparable to what has been reported in previous research (Peeters, et al., 1996; Roelofs, et al., 2005; Van Damme, et al., 2002). Scores on the FPQ were positively correlated with those on the PCS and scores on the PANAS-NA. An overview of participants' mean scores, standard deviations, and ranges for all dependent variables in the three phases are presented in Table 2.

Table 1. Means (*M*), Standard Deviations (*SD*), Cronbach's alpha, and Pearson intercorrelations of the Questionnaires.

Variable	Cronbach's alpha	*M*	*SD*	2	3
1 Pain catastrophizing (PCS)	0.90	17.02	8.42	0.47*	0.19
2 Trait fear of pain (FPQ)	0.91	75.29	14.79	-	0.35*
3 Negative affectivity (PANAS-NA)	0.88	20.81	6.48	-	-

Note. PCS = Pain Catastrophizing Scale, FPQ = Fear of Pain Questionnaire, and PANAS-NA = Positive And Negative Affect Schedule - Negative Affectivity subscale.

* $p < .05$.

Table 2. Means (*M*), Standard Deviations (*SD*), and response ranges for the different dependent variables throughout the three experimental phases.

Phase	Variable	Stimulus type	*M*	*SD*	range
Observation phase	Fear	CS+	5.75	2.81	0-10
		CS-	1.90	2.36	0-9
	Pain unpleasantness	CS+	8.16	1.81	0-10
		CS-	4.11	2.18	0-8
	Pain intensity	CS+	6.62	2.78	0-10
		CS-	2.39	2.83	0-9
Exposure phase	Fear	CS+	3.82	2.84	0-9
		CS-	3.18	2.57	0-8
	Pain unpleasantness	CS+	7.03	2.33	1-10
		CS-	6.90	2.37	0-10
	Latency time (ms)	CS+	3504	1061	1986-6047
		CS-	3394	1043	1837-7178
	Pain intensity 5s	CS+	2.74	2.27	0-8
		CS-	3.16	2.32	0-8
	Pain intensity 10s	CS+	3.67	2.43	0-9
		CS-	3.71	2.41	0-8
	Pain intensity 20s	CS+	4.66	2.47	0-10
		CS-	4.95	2.51	0-9
	Pain intensity 40s	CS+	5.97	2.40	0-10
		CS-	5.82	2.42	0-10
	Pain intensity 60s	CS+	6.49	2.27	0-10
		CS-	6.48	2.42	0-10
Recovery phase	Pain intensity 20s	CS+	3.64	2.65	0-8
		CS-	3.38	2.61	0-8
	Pain intensity 40s	CS+	1.40	1.80	0-6
		CS-	1.36	1.67	0-5
	Pain intensity 60s	CS+	1.06	1.81	0-4
		CS-	0.43	0.83	0-3

Note. CS+ = aversive conditioned stimulus; CS- = neutral conditioned stimulus

3.2 Self-reports concerning the CPT

3.2.1 Observation phase

A main effect of stimulus type was found on *fear of pain*, $F(1,60) = 69.14$, $p < .001$ (*Figure 3*). Participants reported more fear (mean = 5.75, 95% CI = 5.04-6.47) with regard to the CS+ task compared to the CS- task (mean = 1.90, 95% CI = 1.30-2.50). In addition, pain catastrophizing, fear of pain, and negative affectivity scores were associated with fear reports, $F(1,59) = 19.65$, $p < .001$; $F(1,59) = 20.36$, $p < .001$; $F(1,59)$ 5.84, $p = .02$, respectively. Participants with a higher score on the measures of these constructs reported more fear regarding both CPT. A significant PANAS-NA x Stimulus type interaction was found on pain-related fear, $F(1,59) = 4.20$, $p = .04$, indicating that negative affectivity moderated the observational fear learning effect. Participants with lower negative affectivity reported more pain-related fear concerning the CS+ compared to the CS-, $F(1,59) = 19.53$, $p < .001$. The difference in pain-related fear between CS+ and CS- was even more pronounced in participants with higher negative affectivity, $F(1,59) = 56.18$, $p < .001$ (*Figure 4*). Concerning the CS+ task, participants scoring higher on negative affectivity reported more pain-related fear compared to lower scorers, $\beta = 0.36$, $p = .004$. Concerning the CS- task, no difference on pain-related fear was found between lower and higher levels of negative affectivity ($\beta = 0.04$, ns) (*Figure 4*). In contrast to our expectations, pain catastrophizing (PCS) and trait fear of pain (FPQ) did not moderate this observationally learned fear of pain, $F(1,59) = 0.57$, ns; $F(1,59) = 3.85$, ns, respectively.

Concerning *expected pain unpleasantness*, a main effect of stimulus type was found, $F(1,60) = 117.47$, $p < .001$ (*Figure 3*). Participants expected pain to be more unpleasant (mean = 8.16, 95% CI = 7.70-8.63) when being exposed to the CS+ task compared to the CS- task (mean = 4.12, 95% CI = 3.56-4.67). No main effects of pain catastrophizing, $F(1,59) = 3.31$, $p = .07$, fear of pain, $F(1,59) = 1.03$, ns, or negative affectivity, $F(1,59) = 0.30$, ns, were found. Furthermore, scores on these measures did not moderate the relationship between stimulus type and expected pain unpleasantness, $F(1,59) = 0.76$, ns; $F(1,59) = 0.70$, ns; $F(1,59) = 2.27$, ns, respectively.

With regard to *expected pain intensity*, a main effect of stimulus type was found $F(1,60) = 59.37$, $p < .001$ (*Figure 3*). Participants expected more intense pain with respect to the CS+ task (mean = 6.62, 95% CI = 5.91-7.33) compared to the CS- task (mean = 2.39, 95% CI = 1.67-3.12). No main effects of PCS, $F(1,59) = 1.73$, ns, FPQ, $F(1,59) = 3.47$, $p = .07$ or PANAS-NA, $F(1,59) = 0.45$, ns, were found. Pain catastrophizing, fear of pain and negative

affectivity did not moderate the relationship between stimulus type and expected pain, $F(1,59) = 0.78$, ns; $F(1,59) = 0.80$, ns; $F(1,59) = 1.91$, ns, respectively.

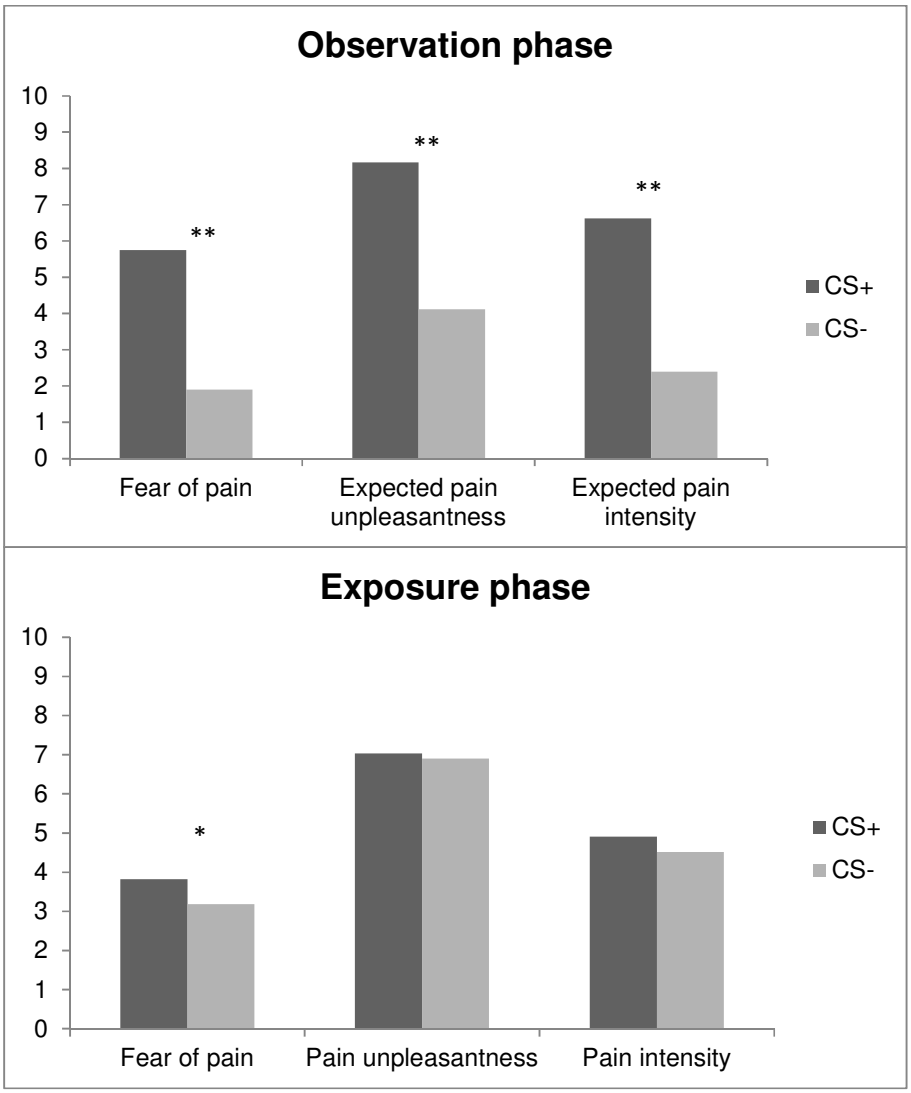


Figure 3. Self-reports concerning the CPT after watching the video (observation phase) and after each immersion (exposure phase).

* $p < .05$, ** $p < .001$.

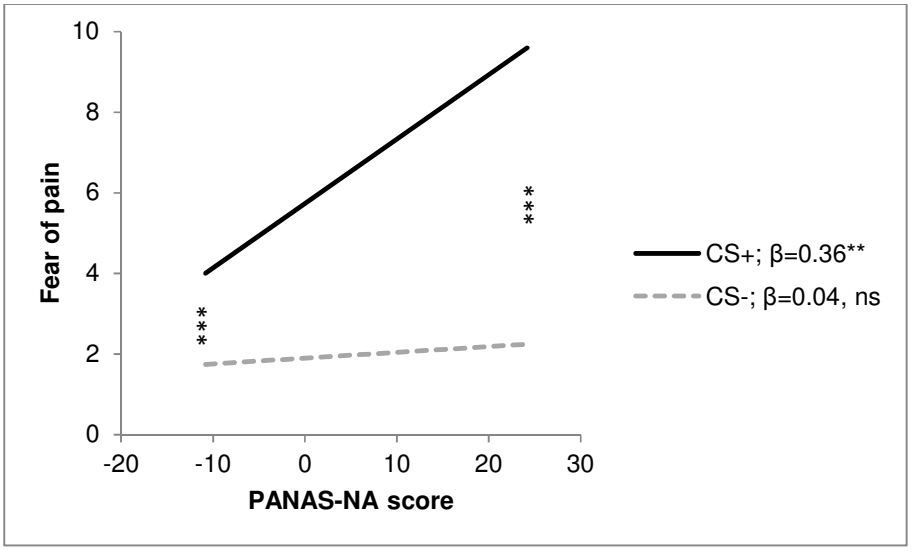


Figure 4. Observation phase. Negative affectivity (PANAS-NA) moderated the relationship between stimulus type and pain-related fear during the observation phase. Regression lines for both stimulus types are shown. Scores of the questionnaires were centred. ** $p < .01$, *** $p < .001$

3.2.2 Exposure phase

Results of the exposure phase are shown in *Figure 3*. After first-hand experience with the CPT, main effects on *pain-related fear* were found for stimulus type, $F(1,60) = 5.34$, $p = .02$, pain catastrophizing, $F(1,59) = 14.98$, $p < .001$, and trait fear of pain, $F(1,59) = 18.68$, $p < .001$, despite equal temperature of both CPT. More fear was reported with regard to the CS+ task (mean = 3.87, 95% CI = 3.14-4.60), compared to the CS- CPT (3.18, 2.52-3.84). Participants who scored high on PCS and/ or FPQ reported more fear during both CPT, compared to low scorers. No main effect of negative affectivity was found, $F(1,59) = 3.35$, $p = .07$. Pain catastrophizing, trait fear of pain, and negative affectivity did not moderate this observational fear learning effect, $F(1,59) = 0.27$, ns; $F(1,59) = 0.26$, ns; $F(1,59) = 2.49$, ns, respectively.

For *pain unpleasantness* ratings, no main effects of stimulus type $F(1,60) = 0.17$, ns, pain catastrophizing, $F(1,59) = 0.29$, ns, fear of pain, $F(1,59) = 0.84$, ns, or negative affectivity, $F(1,59) = 0.29$, ns, were found. However, a Stimulus type x PCS interaction was found, $F(1,59) = 4.70$, $p = .03$, indicating that pain catastrophizing moderated the observational learning effect on pain unpleasantness. However, no difference in pain unpleasantness was reported between the CS+ and CS- CPT in low catastrophizers, $F(1,59) =$

1.57, ns, or high catastrophizers $F(1,59) = 3.35$, ns. Neither did the regression analyses for both stimulus types separately reveal any significant relation with pain unpleasantness (CS+: $\beta = 0.20$, ns; CS-: $\beta = 0.08$, ns) (*Figure 5*). Trait fear of pain, $F(1,59) = 0.93$, ns, and negative affectivity, $F(1,59) = 0.37$, ns, did not show a moderating effect.

The course of *pain intensity* during exposure was investigated by means of repeated measures ANOVA with stimulus type and time as within subject variables (*Figure 6*). A main effect of time was found for pain intensity during immersion, $F(1.91,89.59) = 156.45$, $p < .001$, with pain experience increasing over time. No main effect of stimulus type was found, $F(1,47) = 0.69$, ns, indicating that the observational fear learning effect did not generalize toward experienced pain. In addition, no interaction was found between stimulus type and time, $F(2.96,139.22) = 1.41$, ns, indicating that pain intensity across time was similar for the CS+ and the CS- task. High pain catastrophizers and participants with high fear of pain scores reported more pain during immersion compared to low scorers, $F(1,46) = 5.12$, $p = .03$; $F(1,46) = 4.06$, $p = .05$, respectively. No main effect of negative affectivity was found during immersion, $F(1,46) = 0.002$, ns. Pain catastrophizing, trait fear of pain, and negative affectivity did not moderate the relationship between stimulus type and pain intensity ratings, $F(1,46) = 0.02$, ns; $F(1,46) = 0.006$, ns; $F(1,46) = 0.11$, ns, respectively.

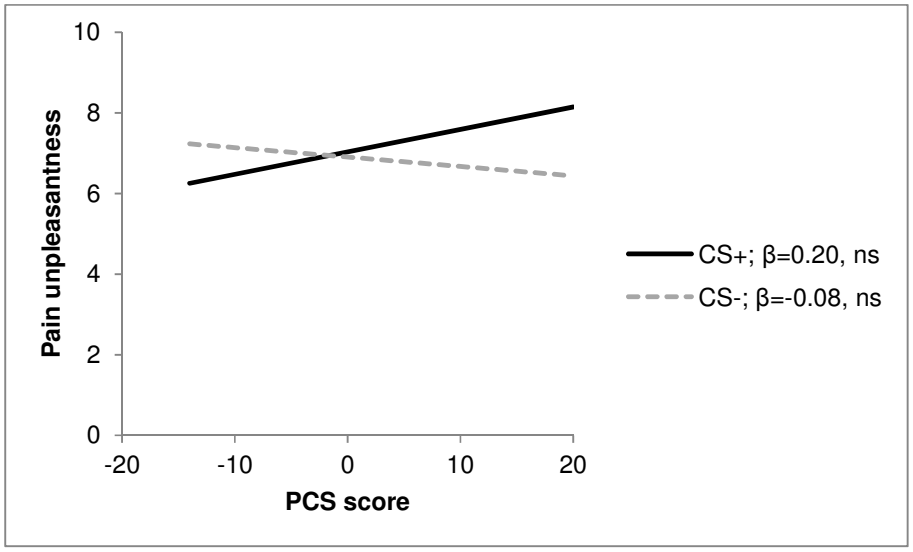


Figure 5. Exposure phase. Pain catastrophizing moderated the association between stimulus type and pain unpleasantness during the exposure phase. Regression lines for both stimulus types are shown. Scores of the questionnaires were centred.

3.2.3 Recovery phase

Analyses of *pain intensity ratings* one minute *after immersion* revealed a main effect of time, $F(1.31,77.38) = 116.08$, $p < .001$, with pain intensity diminishing over time. No main effect of stimulus type was found, $F(1.59) = 2.37$, ns, indicating that pain ratings were similar for both CPT. Additionally, pain ratings across time were similar for both CPT, as no interaction was found between stimulus type and time $F(1.43,84.29) = 0.81$, ns. Main effects were found for pain catastrophizing, $F(1,58) = 4.08$, $p = .05$, and trait fear of pain, $F(1,58) = 14.06$, $p < .001$. Participants with high PCS and/ or FPQ scores reported more pain compared to low scorers. No main effect of negative affectivity was found after immersion, $F(1,58) = 1.17$, ns. Pain catastrophizing, trait fear of pain, and negative affectivity did not moderate the relationship between stimulus type and pain intensity ratings during recovery, $F(1,58) = 0.23$, ns; $F(1,58) = 0.49$, ns; $F(1,58) = 0.11$, ns, respectively.

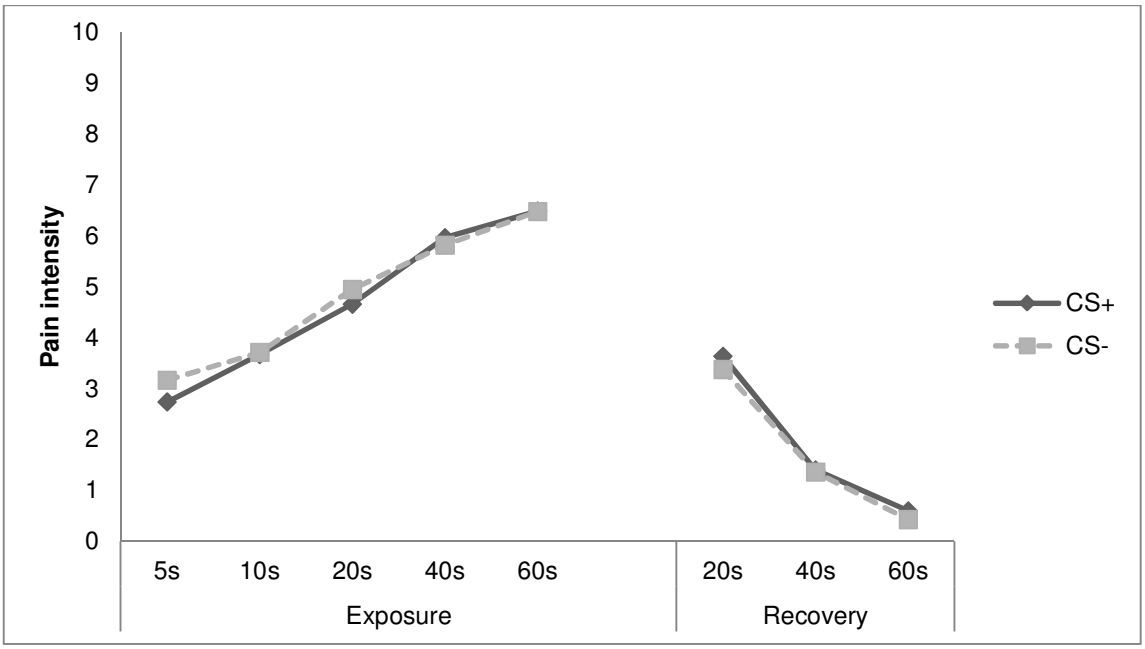


Figure 6. Pain intensity ratings during exposure (left) and recovery (right).

3.3 Avoidance behaviour

Latency time was available only for 50 participants (81%), due to technical difficulties occurring in the course of the experiment. No difference between the CS+ and CS- task was found with regard to immersion latency (suppression of the button), $F(1,49) = 0.36$, ns, although participants had the impression to be more indecisive before starting the CS+ task, $F(1,61) = 18.62$, $p < .001$ (self-reports, CS-: mean = 2.02, SD = 2.25; CS+: mean = 3.40, SD = 2.96). There were no early withdrawals in either task. When being asked which of the two CPT they would choose when requested to perform one additional CPT, only 50% of the participants preferred to repeat the CS- task. Hence, no avoidance behaviour was observed regarding the CS+ task, suggesting that both CPT were perceived equally aversive.

3.4 Contingency awareness

The picture sorting task to assess contingency awareness revealed that 95% of the participants were aware of the contingency between colour and facial expression. Awareness data of two participants were missing. However, data of all participants were included in statistical analyses as contingency awareness is not a necessary feature for differential fear conditioning in pain (Wunsch, Philippot, & Plaghki, 2003).

4 Discussion

Although there is accumulating research evidence supporting the fear-avoidance model in explaining pain-related interference with daily life activities, literature on the acquisition of pain-related fear is scarce (Leeuw, et al., 2007). The primary aim of this study was to investigate whether pain-related fear develops by observing others displaying pain behaviour. Using a differential fear conditioning procedure, participants watched a video showing human models performing coloured cold pressor tasks (CPT). Participants were informed that they would perform the same tasks afterwards. One colour (CS+) was associated with painful facial expressions of the video models; the other (CS-) with neutral faces (counterbalanced). The results showed that participants reported more *pain-related fear* when anticipating the CPT associated with the painful expressions (CS+). They also expected this task to be more *unpleasant* and *painful* than the CS- task. After first-hand exposure to the CPT, no difference was found with regard to *pain intensity* or *pain unpleasantness*, although participants still reported more *pain-related fear* regarding the CS+. During recovery, pain intensity ratings regarding both CS+ and CS- tasks rapidly diminished. Furthermore, negative affectivity was associated with facilitated acquisition of pain-related fear.

The present study is one of the first to provide evidence for observational learning of pain-related fear beliefs in humans. In general, three pathways have been considered in the aetiology of fear: experiential learning (i.e., fear develops after direct experience with the aversive stimulus) (Rachman, 1977), instructional learning (i.e., transmission of verbal information about the aversive stimulus) (Field & Lawson, 2003; Muris, et al., 2003), and observational learning (i.e., learning as a consequence of observing others' behaviours encountering an aversive stimulus). Common to these pathways is that a neutral stimulus acquires motivational qualities after being functionally associated with an aversive stimulus. Although it is widely accepted that knowledge about fear-related objects or situations can be acquired by social observation (Rachman, 1977), the evidence is meagre, and related studies in the area of pain-related fear almost non-existent. In addition, much of the available evidence on observational fear learning has been obtained using retrospective self-reports (King, et al., 1998). During the last decade, however, experimental evidence has been generated for observational learning as a pathway to fear in children. Toddlers displayed greater fear expressions and avoidance behaviour towards a novel fear-relevant toy (plastic snake or spider) after witnessing their mothers with fear and disgust expressions towards that toy (2002). Similarly, children exposed to pictures of novel animals paired with pictures of either scared, happy or no facial expressions displayed more avoidance behaviour to the animals that they had previously seen paired with scared faces (2007). In the context of *pain*, most research has focused on the influence of modelling on pain intensity, threshold and tolerance. For example, Craig and Weiss (1971) examined the impact of pain tolerant and intolerant social models on students' verbal pain reports induced by electrical stimulation. There was a significant impact on both pain expressions and willingness to accept pain stimuli of increased intensity. More recently, Olsson et al. (2004) demonstrated that observational fear learning occurred through observation of the emotional expression of a confederate receiving shocks paired with a CS+ (angry male faces).

The results of the current study show that pain-related fear can be acquired by healthy subjects observing another person displaying pain behaviours when being in contact with an ambiguous stimulus. Not only are subjects aware of the contingencies between the facial expressions and the colour of the CPT's, they indeed report more fear for the CS+, and expect the CS+ to be more painful. Despite the ambiguous but equal temperature of both CPT, fear of pain did not totally extinguish after the actual exposure to the water although the difference in fear ratings is much lower than after the observation phase. Possibly, repeated exposures

are needed for fear to extinguish totally (Marks, 1987). Despite the difference in fear levels after immersion, no differences in pain intensity and unpleasantness were reported. This is in contrast with the study of Arntz and Claassen (2004), in which fear beliefs were found to increase pain intensity ratings during exposure. One possible explanation for the absence of a differential effect on pain intensity may relate to the temperature of the CPT. Pain intensity ratings rapidly increased throughout both immersions. Consequently, participants might have perceived both tasks as aversive/painful, rather than ambiguous. The results of the behavioural measures used in the current experiment revealed no difference between the two tasks regarding immersion latency. One possible explanation for the absence of this differential effect might be related to the peremptory nature of the instruction (participants were asked to immerse their hand into the liquid as soon as the instruction appeared on the computer screen). Perhaps a better instruction would have been to ask participants to immerse their hand into the water whenever they felt ready to do so. Furthermore, participants did not show a preference for the CS- task when they were asked which task they would prefer to repeat. These findings raise the question under which conditions observationally learned fear translates into avoidance behaviour. Personal relevance or needs of the observer might play an important role in this process (Goubert, et al., 2011). Potentially painful situations may be more salient and relevant to pain patients compared to healthy controls, thereby facilitating the translation of fear beliefs into overt avoidance. The current findings may have implications in the context of clinical pain, although we have to be cautious in generalizing these results to a clinical population. Regarding the acquisition of pain-related fear, it is possible that relatives or friends of pain patients who witness these individuals avoiding particular situations or movements because of their pain-related fear, learn a contingency between avoiding and (relief of) pain. Later in life, when experiencing pain themselves, this latent knowledge may become activated, and may potentiate avoidance behaviour, a process by which an individual may enter a downward spiral of increasing disability and pain (Vlaeyen & Linton, 2000). Furthermore, the results suggest that individuals with higher negative affectivity may be more prone to develop pain-related fear. Negative affectivity is a general dimension of subjective distress that subsumes a variety of aversive mood states, including fear (Watson, et al., 1988). This finding extends prior research indicating that individuals reporting higher negative affectivity show hypervigilance to different forms of threat, and therefore are assumed to be more vulnerable to develop specific fears (Eysenck, 1992).

It is likely that the strength of observational learning also depends upon the nature of the relationship between model and observer, with models perceived as in closer proximity having more impact than those perceived as belonging to an 'outgroup' (Goubert, et al., 2005; Williams, 2002). In the current study, pain sufferers and observers were strangers to each other. Accordingly, observational learning effects may be larger when the pain sufferer is a spouse or an acquaintance. In addition, the observer's capacity to empathize with the model might influence the experienced distress (Goubert, et al., 2005).

Knowledge about pain-related fear acquisition may help developing novel pain management programs, since this fear can be more disabling than the pain itself, and is one of the risk factors leading to chronic disability (Crombez, et al., 1999). Results of the current study suggest that observing others expressing pain may lead to an increase in pain-related fear beliefs and enhanced pain intensity expectancy. Extinction of pain-related fear for the CPT was tested through actual experience of the CPT. It would be interesting to test whether extinction can also be established by observing another person being exposed to the CPT without the painful expression as the US. Such a technique might also be useful in pain treatments. Witnessing a model acting fearless with respect to a painful stimulus or situation may be a protective factor in fear learning, resulting in decreased pain intensity expectancy, which in turn might lead to reduced subjective pain experience and pain-related brain activation (Koyama, McHaffie, Laurienti, & Coghill, 2005).

There are several limitations to this study, yielding implications for future research. First, an important limitation is the lack of a baseline measure for pain-related fear for the CPT, precluding statistical control for differences on this measure in testing fear acquisition through observation. Second, Lang (1968) conceptualized fear as three relatively independent response systems: language behaviour (self-reports), physiological responses, and avoidance behaviour. In the current study only self-reports and behavioural measures were included. Future studies should comprise sensitive, reliable measures for all three fear components. Third, only facial pain expressions of the models were used. We expect the observational learning effect to be stronger if the faces are accompanied by vocal expressions and total body movements. This would also increase the ecological validity of the unconditioned stimuli (De Gelder, Snyder, Greve, Gerard, & Hadjikhani, 2004). Nonetheless, differential effects after observation of the video models were quite pronounced. Finally, participants were all healthy young females, which restricts external validity and further studies are needed to test whether our findings generalize to male samples and individuals suffering acute or chronic pain.

Despite these limitations, the findings of this study provide preliminary evidence for observational learning of pain-related fear beliefs in humans. Participants feared the CS+ CPT after witnessing models' pain expressions, indicating that direct experience is not a necessary feature for the acquisition of pain-related fear.

CHAPTER III:

Indirect Acquisition of Pain-related Fear:

An Experimental Study of Observational Learning using Coloured Cold Metal Bars

Abstract

Previous research has demonstrated that pain-related fear can be acquired through observation of another's pain behaviour during an encounter with a painful stimulus. We present the results of two experimental studies, each with a different pain stimulus, of which the aim was to investigate the effect of observational learning on pain expectancies, avoidance behaviour, and skin conductance responses. Additionally, changes in pain-related fear, pain unpleasantness, intensity, and perceived harmfulness, after exposure to the stimuli were examined. During the observation phase, healthy female participants watched a video showing coloured cold metal bars being placed against the neck of several models. In a differential fear conditioning paradigm, one colour was paired with painful facial expressions (CS+), and another colour was paired with neutral facial expressions of the video models (CS-). During the exposure phase, both metal bars with equal temperatures were placed repeatedly against participants' own neck. Results showed that watching the video induced pain-related fear, and caused the participants to expect higher pain unpleasantness, pain intensity, and perceived harmfulness regarding the CS+ bar, compared to the CS- bar. However, these observationally acquired expectancies did not result in behavioural changes. Skin conductance responses were higher when exposed to the CS+ bars, but only in one of two experiments. During actual exposure to both the CS+ and CS- bars, no differences in pain-related fear, pain, and perceived harmfulness between the CS+ and CS- bar were observed. Results are discussed in the light of recent theories on pain and fear learning.

Key words: Observational learning; pain-related fear; facial expressions

1 Introduction

Chronic pain is one of the major health problems in Western societies, with a prevalence of 19% (Breivik, et al., 2006; Gatchel, et al., 2007; Von Korff, et al., 2005). Not only does chronic pain account for enormous health care costs and lost working productivity, it also results in a substantial quality of life reduction (Breivik, et al., 2006; Kronborg, Handberg, & Axelsen, 2008). An important predictor in the development as well as the continuation of chronic pain problems is pain-related fear (Asmundson, Norton, & Vlaeyen, 2004; Boersma & Linton, 2005; Leeuw, et al., 2007; Turk & Wilson, 2010). The idea is that it instigates catastrophic ruminations about pain and avoidance behaviour which interfere with cognitive, physical and social functioning (Gheldof, et al., 2010; Helsen, et al., 2013).

Despite its demonstrated importance, little is yet known about how pain-related fear is acquired. In accordance with Rachman's three pathways theory of fear acquisition, pain-related fear is expected to be acquired through direct experience (Rachman, 1977, 1991), verbal instruction (Field & Lawson, 2003; Muris, et al., 2003; Olsson & Phelps, 2007), and mere observation (Askew & Field, 2007; Askew & Field, 2008). Recently, researchers have shown increased interest in the observational learning pathway to pain-related fear (Goubert, et al., 2011), described by Bandura (1986) as '*changes in patterns of behaviour that are a consequence of observing others' behaviour*'. In a previous study using coloured cold pressor tasks (CPT) (Helsen, Goubert, Peters, & Vlaeyen, 2011), evidence was found for the acquisition of fearful expectancies through observation. In this study, participants watched models displaying painful facial expressions during immersion of the hand in a CPT with one colour (CS+), and neutral expressions during a CPT with another colour (CS-). Despite differential pain expectancies, no differences in avoidance behaviour were observed. After watching the video, participants were requested to consecutively immerse their hand in each CPT. Despite equal temperatures, they expressed more pain-related fear when exposed to the CS+ CPT.

The main objective of the current study was to examine both observational acquisition and direct extinction (i.e., extinction through repeated first-hand exposure to the feared stimulus) of pain-related fear, including measures of pain expectancy, avoidance behaviour and psychophysiological responding (1968). We employed a differential fear conditioning paradigm, during which participants watched video models exposed to one of two coloured metal bars in their neck displaying either a painful (CS+ colour) or a neutral (CS- colour) facial expression. Afterwards, participants were directly and repeatedly exposed to both metal bars, which had equal temperatures. We predicted that during the observation phase,

participants would experience more pain-related fear regarding the CS+, and expect contact with this bar to be more unpleasant, painful, and harmful in comparison to the CS- bar, consequently eliciting stronger avoidance behaviour. During the exposure phase, differences in pain-related fear, pain unpleasantness, pain intensity, and perceived harmfulness between the CS+ and the CS- bar were assumed to diminish gradually. Additionally, differential skin conductance responses (SCR) were hypothesized during anticipation and presentations of the CS+ and CS- bar respectively, with stronger SCR towards CS+ bars. Given that bars had equal temperatures, differential responding to the two bars was expected to diminish throughout the exposure phase. Finally, we expected observers' pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy to facilitate observational learning. We conducted two experiments, each with different bar temperatures.

EXPERIMENT 1

2 Method

2.1 Participants

Participants were healthy female undergraduate students (N=49), who received either a course credit or eight Euros for their participation in the study. Exclusion criteria were the experience of chronic pain and colour blindness. All participants were Caucasian, with a mean age of 20.47 years (*SD* = 3.76, range 15-42). They were told that the study investigated responses to stimuli of different temperatures. Ethical approval was obtained from the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium).

2.2 Materials

2.2.1 Observation Video

An observation video clip was developed for this study, showing four female human models being exposed to coloured metal bars (conditioned stimuli, CS) in a similar way as in a previous study by Arntz and Claassen (2004). Models were females with a mean age of 24.25 years (*SD* = 2.22, range 22-27) who were requested to mimic painful facial expressions that served as the unconditioned stimuli (US). One coloured bar was always associated with painful facial expressions (CS+), the other with neutral facial expressions (CS-). Each model was shown three times, which resulted in a 12-trial video clip. The CS+ and CS- metal bars

were presented six times each, with a maximum of two consecutive trials of the same type. The colour of the CS+ was counterbalanced: Half of the participants watched a video with an orange metal bar associated with the painful facial expressions; the other half watched a video in which a pink metal bar was associated with the pain expressions. Total duration of the video was about 5 minutes.

2.2.2 Conditioned Stimuli

The metal bars (aluminium, length 17.0 cm, diameter 2.0 cm), which were placed against participants' neck, were coloured with a spray (Motip Dupli®, orange, 466663; pink, 470998) and cooled down in a freezer to approximately -25°C. A previous study (Arntz & Claassens, 2004) showed that an exposure time of one second at this temperature creates an ambiguous stimulus. The same bars were used in the observation video. During the observation video as well as during the actual exposure to participants' neck, not more than two consecutive trials of the same coloured bar were presented.

2.3 Measures

2.3.1 Contingency Awareness

Participants' awareness of the contingency between the colour of the metal bars and the facial expressions of the video models (painful vs. neutral) was measured with a categorisation task. At the end of the experiment, participants were shown one black-and-white picture of each video extract, with clearly visible facial expressions of the models being touched by the bars. They were requested to categorise these pictures into two piles: one pile was associated with the pink, and the other with the orange metal bar. Afterwards, they were asked which criterion they had used to categorise the pictures.

2.3.2 Self-reports

Seven numerical rating scales (NRS) regarding properties of being in contact with the metal bars were presented. For the current study, only the pain-related fear, pain intensity, perceived harmfulness, and pain unpleasantness scales were of interest. The former three scales ranged from 0 (*not at all*) to 10 (*very much*), the latter from -5 (*very unpleasant*) to 5 (*very pleasant*). During the baseline and observation phase, these scales referred to participants' expectations, while during the exposure phase, the scales inquired about their actual experiences. At the end of each phase, self-reported behavioural avoidance tendencies (BAT) were measured. Participants rated on a NRS ranging from 0 (*not at all*) to 10 (*very much*) their willingness to touch each metal bar.

2.3.3 Avoidance Behaviour: The Approach-Avoidance Task (AAT)

The approach-avoidance task, used to assess approach and avoidance tendencies regarding particular stimuli, is a categorisation task based on the compatibility principle. This means that, although the content of the presented stimuli is irrelevant for the instruction of the task, participants' reaction time (RT) is affected by the compatibility between the response and the valence of the stimuli (De Houwer, 2003). The task used in the current experiment was adapted from Rinck and Becker (2007), and compatibility scores were used as an indirect behavioural measure for pain-related fear.

For this task, a joystick (Logitech®, type Attach 3TM), which was glued to the table, was positioned between the participant and a computer screen. Pictures of six stimuli, including the two coloured metal bars used in the experiment, were presented on the screen, either vertically or horizontally oriented. The pictures of the four additional stimuli (filler stimuli) represented neutral objects that one could easily categorise as being horizontally or vertically oriented (an apple corer, a pepper mill, a pencil, and a spoon). In order to create a zooming effect to simulate the approach or avoidance of a particular stimulus, every picture was available in seven pixel sizes (99x132, 165x220, 225x300, 300x400, 360x480, 420x560, 510x680) (Rinck & Becker, 2007), and every picture size corresponded to one of seven imaginary regions on the computer screen (10-110, 110-210, 210-310, 310-458, 458-558, 558-658, 658-758 pixels height, respectively). There were two imaginary end regions: one at the top (0-10 pixels), and one at the bottom (758-768 pixels) of the screen. Each trial was initiated by the participant pushing the start button of the joystick, which was then followed by the display of the medium-sized picture. Picture size changed whenever the hidden cursor of the joystick entered a different region. For instance, when pushing the joystick away, the cursor entered the 310-210 pixel region, which resulted in presentation of the smaller 225x300 pixel size picture. When pushing the joystick even further, picture size further decreased, which seemed to enlarge the distance between the participant and the stimulus. When entering the end region, the picture disappeared, irrespective of the response accuracy. Similarly, when participants pulled the joystick towards themselves, the picture size gradually increased, which gave the impression of an approaching stimulus. Movements to the left or right had no effect.

Participants were instructed to pull the joystick towards themselves whenever they saw a picture of a vertically oriented object on the computer screen, and to push the joystick away when a horizontally oriented object was shown, or vice versa (counterbalanced). They

were requested to do this as quickly and accurately as possible. The task, which comprised 88 trials, was administered in each of the three phases (baseline, observation, and exposure). The two pictures showing a metal bar were presented 10 times in both horizontal and vertical orientation. The four filler stimuli were presented six times in each orientation. Pictures were presented randomly with the restrictions that the first two pictures never displayed a metal bar, and that consecutive trials did not show the same picture. During the baseline phase, a practice phase consisting of 12 trails preceded the actual AAT: Every stimulus was randomly presented in both orientations. Only during these practice trials, participants received feedback about the accuracy of their answers.

2.3.4 Physiological arousal: Skin Conductance Responses

During the exposure phase, skin conductance responses (SCR) to the pictures of the metal bars measured the level of participant's arousal while they were anticipating the actual exposure to each stimulus, while SCR to the presentations of the metal bars were measured to determine the level of participant's arousal during the actual exposure.

Electrodermal activity was measured using the Coulbourn skin conductance coupler (V71-23). Two standard Ag/AgCl electrodes (diameter 0.8 cm), with an inter-electrode distance of 2.0 cm, were filled with KY gel (Johnson & Johnson®), and placed on the hypothenar eminence of the non-dominant hand, which was scrubbed and cleaned with tap water before the start of the experiment. The skin conductance coupler maintained a constant 0.5 V across the electrodes. The analogue signal was converted with a 12-bit AD-transducer and digitised at 10 Hz. Skin conductance was recorded using Affect 4.0 software (Spruyt, et al., 2010) and treated offline with Psychophysiological Analysis software (PSPHA) (De Clercq, Verschuere, De Vlieger, & Crombez, 2006).

2.3.5 Observers' Characteristics

2.3.5.1 *Pain Catastrophizing*

The Pain Catastrophizing Scale (PCS) (Sullivan, et al., 1995; Van Damme, et al., 2002) is a 13-item self-report measure used in both clinical and non-clinical populations to assess catastrophic thinking about pain. Participants were asked to indicate on a 5-point scale (*0 = not at all; 4 = always*) the degree to which they experienced negative thoughts and feelings during painful situations. Although three subscales can be distinguished (rumination, magnification, and helplessness), only the total score was of interest in the current study. High internal consistency of this sum score was found (Cronbach's alpha = .87), which is

comparable to the reliability found in previous studies (Cronbach's alpha = .85- .91) (Crombez, Eccleston, Baeyens, & Eelen, 1998; Crombez, et al., 1999).

2.3.5.2 *Trait Fear of Pain*

Trait fear of pain was measured by means of the Fear of Pain Questionnaire (FPQ-III) (McNeil & Rainwater, 1998; Roelofs, et al., 2005), which includes 31 descriptions of specific painful situations. Participants were requested to rate the degree of fear they anticipated to experience in each situation (*A = no fear at all; E = extreme fear*). Reliability of the total score was very good (Cronbach's alpha = .90). Previous studies have shown good reliability and validity of the FPQ-III in both clinical and non-clinical populations (McNeil & Rainwater, 1998; Osman, et al., 2002).

2.3.5.3 *Trait Negative Affectivity*

In order to assess negative affectivity, the Trait version of the Positive And Negative Affect Schedule (PANAS) (Peeters, et al., 1996; Watson, et al., 1988) was administered. Participants reported the degree by which they experienced 20 different emotions in daily life (*very little*; *very often*). Half of the adverbs described positive emotions, the other half negative emotions. In the current study, only the Negative Affectivity subscale (PANAS-NA) was utilized, containing the sum score of the 10 negative adverbs. Internal consistency of this subscale was good (Cronbach's alpha = .82), which is comparable to previous research (Cronbach's alpha = .83-.87) (Peeters, et al., 1996; Watson, et al., 1988).

2.3.5.4 *Intolerance of Uncertainty*

The Intolerance of Uncertainty Scale (IUS) (Buhr & Dugas, 2002; de Bruin, Rassin, van der Heiden, & Muris, 2006) consists of 27 items mentioning different propositions regarding uncertain or ambiguous situations or future events. Participants were requested to indicate to what extent they agreed with these propositions (*1 = highly disagree; 5 = highly agree*). Despite the multifactor structure, this questionnaire is most commonly summed as a total scale score (Roemer, 2001), with higher scores representing greater intolerance of uncertainty. The IUS was found to have high internal consistency (Cronbach's alpha = .80), although previous studies using the Dutch IUS showed even higher consistency (Cronbach's alpha = .88 in a student sample, and .94 in a sample of patients with anxiety disorder) (de Bruin, et al., 2006). Test-retest reliability of the IUS was found to be acceptable over a four-week period ($r = .79$, $p < .001$) (de Bruin, et al., 2006).

2.3.5.5 *Dispositional Empathy*

The Interpersonal Reactivity Index (IRI) (Davis, 1980; Davis, 1983; De Corte, et al., 2007) is a self-report measure to assess dispositional empathy, consisting of 28 reflecting thoughts and feelings one can experience in interpersonal contexts. Participants were asked to indicate to what extent the statements described them (*A = does not describe me well; E = describes me very well*). The IRI encompasses four subscales: Perspective Taking (PT; i.e., the tendency to adopt another's psychological point of view), Fantasy (FS; i.e., the tendency to identify strongly with the feelings and actions of fictitious characters), Empathic Concern (EC; i.e., the tendency to experience feelings of warmth, sympathy, and concern for unfortunate others), and Personal Distress (PD; i.e., the tendency to experience feelings of discomfort and concern when witnessing others' distress) (Davis, 1983). Cronbach's alphas for the separate subscales were .77, .81, .70, .64, respectively. Previous studies using the Dutch IRI have also found satisfactory internal consistency (Cronbach's alphas = .73, .83, .73, .77, respectively) (De Corte, et al., 2007).

2.4 Procedure

After being informed about the course of the experiment, participants signed the informed consent form. Prior to the start of the experiment, the questionnaires (PCS, FPQ, IUS, IRI, and PANAS) were completed. Participants were then asked to scrub the palm of the non-dominant hand and to rinse it with tap water before the electrodes were attached to the hypothenar eminence.

The experiment consisted of three phases: (1) baseline, (2) observation, and (3) exposure (see *Figure 7*). During the *baseline phase*, participants were requested to report their expectations concerning pain-related fear, pain unpleasantness, pain intensity, and harmfulness. Next, the AAT was administered. At the end of the baseline phase, participants rated their willingness to touch both bars (self-reported behavioural avoidance tendency). During the *observation phase*, participants watched the models in the video clip showing either painful or neutral facial expressions when exposed to the CS+ and CS- metal bar respectively. After rating the self-reported expectancies regarding pain-related fear, pain unpleasantness, pain intensity, and perceived harmfulness, the AAT was performed, and self-reported avoidance tendencies were measured. During the *exposure phase*, both metal bars were placed repeatedly against participants' neck. At the beginning of each trial, a picture showing the upcoming bar appeared on the computer screen for five seconds. About 30 seconds later, the participant was exposed to the bar for approximately one second. Immediately after each exposure, participants were asked to report the degree of pain-related

fear, pain unpleasantness, pain intensity, and harmfulness they had experienced. Skin conductance was recorded throughout this phase. Once the 12 exposure trials were completed, participants completed the AAT, and reported avoidance tendencies regarding both stimuli. At the end of the experiment, contingency awareness was checked, and participants were debriefed about the broader context and purpose of the study.

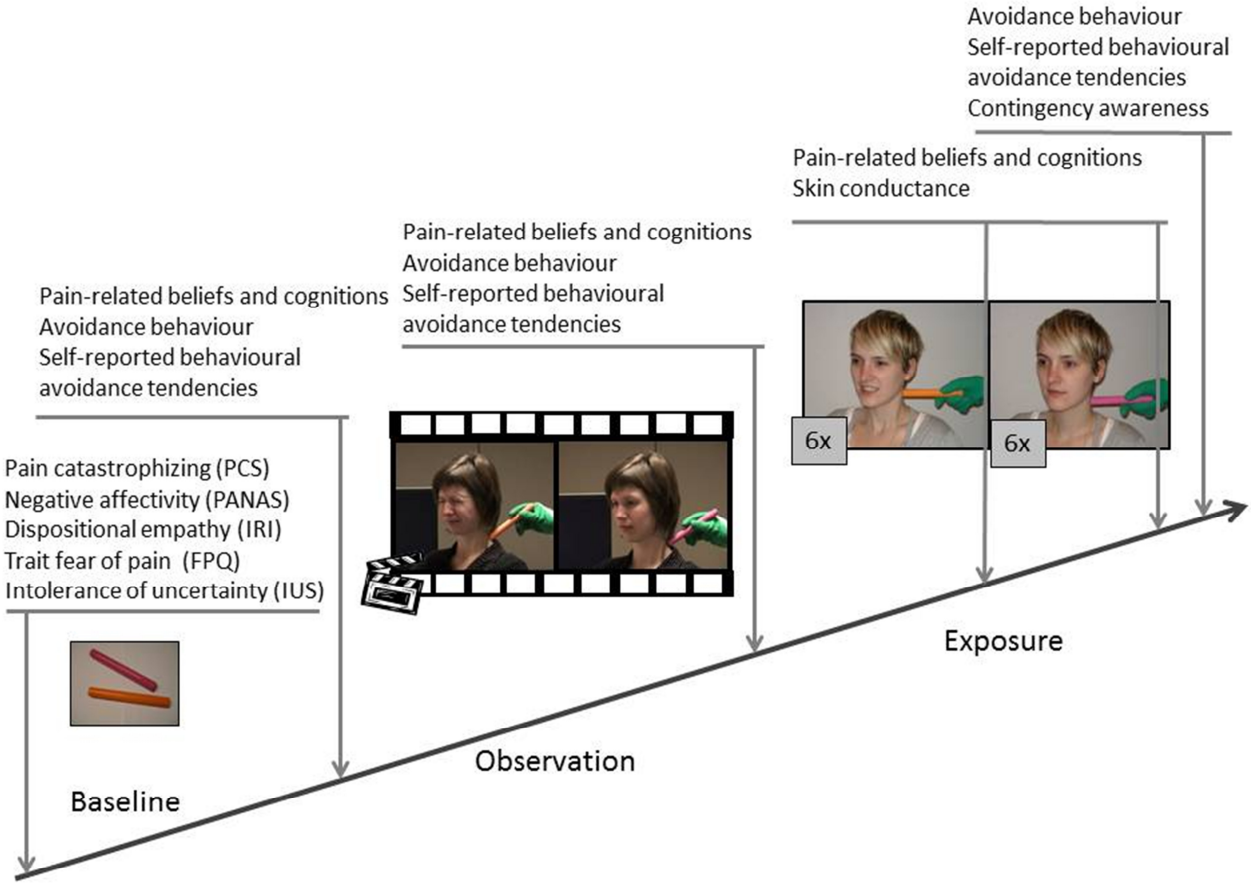


Figure 7. Graphical overview of the experimental procedure, with the measurements during the baseline, observation, and exposure phase. During the observation phase, one color was associated with painful facial expressions of the video models (left), while the other color was paired with neutral expressions (right).

2.5 Data Preparation and Statistical Analyses

Concerning the *AAT*, median RTs per stimulus type (CS+ vs. CS-), per response direction (pulling vs. pushing the joystick) were determined for each participant, excluding RTs of incorrect responses. Subsequently, median scores in the pull condition were subtracted from medians in the push condition for each stimulus type separately to compute compatibility scores. As a result, the relative strength of approach and avoidance regarding the three stimulus types was measured, with positive scores representing stronger approach tendency, and negative scores representing stronger avoidance. *SCR data* were determined with respect to both the pictures of the metal bars and the actual presentations of the bars in the exposure phase. Concerning the *SCR to the pictures*, the mean value in the 2-second window before presentation of the picture was compared to the maximum value of the 8-second window after presentation of either picture. Concerning the *SCR to the presentations of the bars*, the mean value in the 2-second window before presentation of each bar was compared to the maximum value of the 4-second window after presentation of either bar. A logarithmic transformation (Log10(SCR+1)) was performed on the SCR data before statistical testing to reduce skewness.

Mixed model statistical analyses were conducted with stimulus type (CS+ versus CS-) and time (baseline, observation, and exposure) as within-subject factors. For each dependent variable, two models were compared: (1) stimulus type, time and stimulus type x time as fixed effects, and intercept as a random effect, (2) stimulus type, time and stimulus type x time as fixed effects, and intercept and time as random effects. The model with the significantly lowest (full) maximum likelihood produces the best fit. For most dependent variables, the first model (with the random intercept and fixed slope) yielded the best fit. Hence, in order to preserve consistency, all analyses were conducted using this model. The same model was also used in moderation analyses, entering centred PCS, FPQ, IUS, IRI or PANAS-NA scores as covariates. Significant statistical interactions between stimulus type and questionnaire scores denoted moderation effects. Regression analyses were conducted separately for each stimulus type to explore the direction of these effects according to the procedure described by Baron and Kenny (1986). Differential effects (CS+ vs. CS-) for individuals scoring higher or lower on the moderator variable were investigated by centring the covariates around the -1 *SD* (lower moderator scores) or +1 *SD* value (higher moderator scores).

Self-reported acquisition of pain-related fear, pain unpleasantness, pain intensity, and perceived harmfulness were investigated analysing both the baseline and observation phase. Successful acquisition of pain-related fear would be reflected by a significant interaction

between stimulus type and time. For the six measurements of the *self-reported extinction during exposure*, baseline scores, and the interaction between baseline score and stimulus type were included as additional factors. If baseline effects were statistically non-significant, they were deleted from moderation analyses for the corresponding dependent variable. Throughout the exposure phase, *psychophysiological responses* were investigated comparing SCR to the pictures and actual presentations of the six CS+ and six CS- trials. With respect to the analyses of the *self-reported behavioural avoidance tendencies* (BAT), and *the AAT compatibility scores*, all three phases were included together in the analyses. 3-way interactions between stimulus type, time, and scores on the questionnaires were included to examine whether the effects of the observers' characteristics on the relationship between stimulus type and the BAT and compatibility scores varied across time. If the 3-way interaction was significant, a distinction was made between acquisition (baseline x observation phase) and exposure to explore when the effect of the moderator was strongest.

All analyses were conducted with an alpha ≤ 0.05, using SPSS 19.0. Bonferroni corrections were implemented in all pairwise comparisons. The use of mixed model analyses may result in the report of fractionated denominator degrees of freedom, which are obtained by a Satterthwaite approximation (Satterthwaite, 1946).

3 Results

3.1 Sample Characteristics

Descriptive statistics, internal consistency, and Pearson inter-correlations regarding the questionnaire total scores and subscales are summarized in Table 3. Means (*M*), Standard Deviations (*SD*), Cronbach's Alpha, and Pearson Intercorrelations of the Questionnaires.. Mean scores were comparable to what has been reported in previous research (de Bruin, et al., 2006; De Corte, et al., 2007; Peeters, et al., 1996; Roelofs, et al., 2005; Van Damme, et al., 2002).

Table 3. Means (*M*), Standard Deviations (*SD*), Cronbach's Alpha, and Pearson Intercorrelations of the Questionnaires.

	Experiment 1			Experiment 2										
	M	*SD*	Cronbach's alpha	*M*	*SD*	Cronbach's alpha	1	2	3	4	5	6	7	8
1 PCS	15.45	7.40	.87	14.12	6.50	.83		.34*	.30*	-.03	-.06	-.11	.14	.34*
2 IUS	69.64	14.07	.80	68.63	14.49	.90	.05		.20	.20	-.05	.02	.34*	.36*
3 FPQ	77.21	13.90	.90	74.51	14.23	.90	.39**	.22		-.06	-.10	-.12	.24**	.39**
4 IRI PT	21.27	2.84	.77	16.37	4.27	.78	-.25	-.30*	-.33*		.10	.37**	.41**	.06
5 IRI FS	18.40	2.45	.81	18.72	5.84	.90	.14	.14	.25	.05		.40**	.21	.13
6 IRI EC	20.35	2.20	.70	19.19	4.30	.76	.06	.06	.27	.40**	.30*		.26	.07
7 IRI PD	21.63	3.03	.64	13.23	4.62	.81	.01	.32*	.47**	.01	.19	.48**		.48**
8 PANAS NA	20.12	5.32	.82	21.05	6.94	.87	.26	.56**	.39**	-.26	.36*	.13	.27	

Note. The intercorrelation values above the diagonal represent the scores of Experiment 1, whereas the values below the diagonal show intercorrelations of Experiment 2. PCS = Pain Catastrophizing Scale, IUS = Intolerance of Uncertainty Scale, FPQ = Fear of Pain Questionnaire, IRI = Interpersonal Reactivity Index, PT = Perspective Taking, FS = Fantasy, EC = Empathic Concern, PD = Personal distress, and PANAS-NA = Positive And Negative Affect Schedule - Negative Affectivity subscale.

* $p < .05$, ** $p < .01$.

Table 4. Overview of the statistical values for acquisition and exposure of pain-related fear, pain, and harmfulness.

	Experiment 1			Experiment 2		
Acquisition						
	Type	Time	Type*Time	Type	Time	Type*Time
Pain-related fear	$F(1;145,54)= 23,83^{**}$	$F(1;147,02)= 43,83^{**}$	$F(1;145,54)= 32,46^{**}$	$F(1;129)= 42,90^{**}$	$F(1;129)= 58,87^{**}$	$F(1;129)= 40,49^{**}$
Pain unpleasantness	$F(1;194)= 16,93^{**}$	$F(1;194)= 6,74^{*}$	$F(1;194)= 35,27^{**}$	$F(1;129)= 59,46^{**}$	$F(1;129)= 55,65^{**}$	$F(1;129)= 73,76^{**}$
Pain intensity	$F(1;145,60)= 29,32^{**}$	$F(1;147,09)= 33,00^{**}$	$F(1;145,60)= 37,37^{**}$	$F(1;129)= 62,56^{**}$	$F(1;129)= 53,21^{**}$	$F(1;129)= 55,81^{**}$
Harmfulness	$F(1;145,60)= 15,83^{**}$	$F(1;146,98)= 30,63^{**}$	$F(1;145,60)= 27,82^{**}$	$F(1;129)= 37,61^{**}$	$F(1;129)= 16,98^{**}$	$F(1;129)= 29,84^{**}$
Exposure						
	Type	Time	Type*Time	Type	Time	Type*Time
Pain-related fear	$F(1;570,07)= 0,21$	$F(5;527,68)= 1,55$	$F(5;527,68)= 1,23$	$F(1;510,38)= 0,19$	$F(5;472)= 2,73^{*}$	$F(5;472)= 0,37$
Pain unpleasantness	$F(1;502,01)= 2,79$	$F(5;527,95)= 1,96$	$F(5;527,95)= 0,92$	$F(1;447,05)= 1,23$	$F(5;472,88)= 0,40$	$F(5;472,88)= 1,62$
Pain intensity	$F(1;561,31)= 1,59$	$F(5;527,58)= 1,52$	$F(5;527,58)= 0,89$	$F(1;516)= 0,01$	$F(5;516)= 0,18$	$F(5;516)= 0,56$
Harmfulness	$F(1;556,33)= 1,82$	$F(5;527,96)= 0,28$	$F(5;527,96)= 0,67$	$F(1;516)= 0,05$	$F(5;516)= 1,27$	$F(5;516)= 0,19$

Note. *F*-values and significant effects of the self-reports of both experiments.

$^{*}p < .05$, $^{**}p < .001$

3.2 Contingency Awareness

All participants reported awareness of the contingency between the colour of the metal bars and the facial expressions of the video models (painful versus neutral). Categorisation data revealed that 62.2% of the participants correctly categorised all six CS+ pictures as painful, 28.9% made one error, 6.7% made two errors, and 2.2% made more than two errors.

3.3 Self-reported Pain-related Fear, Pain, and Harmfulness

An overview of statistical tests regarding the self-report data for both acquisition and exposure of this experiment can be found in Table 4.

3.3.1 Baseline and Observation Phase

Concerning **pain-related fear** (see Figure 2 A), main effects of stimulus type and time were found, $F(1;145.54) = 23.83$, $p < .001$; $F(1;147.02) = 43.83$, $p < .001$, respectively. In addition, a significant interaction was found between stimulus type and time, $F(1;145.54) = 32.46$, $p < .001$. Participants reported no difference in fear between both stimulus types during baseline, $F(1;49) = 1.24$, ns. During the observation phase, however, more fear was reported concerning the CS+ bar compared to the CS- bar, $F(1;96) = 37.10$, $p < .001$. This difference was due to an increase in fear regarding the CS+, $F(1;97) = 71.50$, $p < .001$, as no difference was found between the two phases with respect to the CS-, $F(1;48.75) = 0.61$, ns.

Main effects of stimulus type and time were found on expected **pain unpleasantness** (see *Figure 8*), $F(1;194)= 16.93$, $p < .001$; $F(1;194) = 6.74$, $p = .01$. Additionally, a significant interaction was found between stimulus type and time, $F(1;194) = 35.27$, $p < .001$. Although no difference between the two bars was hypothesized, participants expected more unpleasantness with regard to the CS- compared to the CS+, during the baseline, $F(1;49) = 5.67$, $p = .02$. During the observation phase, participants anticipated more unpleasantness concerning the CS+, $F(1;96) = 32.01$, $p < .001$. Watching the observation video resulted in both an increase in expected unpleasantness regarding the CS+, $F(1;49.20) = 29.81$, $p < .001$, and a decrease in expected unpleasantness with respect to the CS- metal bar, $F(1;48.96) = 9.56$, $p < .01$.

Main effects of stimulus type and time were found on expected **pain intensity** (see *Figure 8*), $F(1;145.60) = 29.32$, $p < .001$; $F(1;147.09) = 33.00$, $p < .001$. In addition, a significant interaction was found between stimulus type and time, $F(1;145.60)= 37.37$, $p < .001$. During the baseline, participants reported no difference in expected pain intensity between both stimulus types, $F(1; 49) = 1.62$, ns, whereas during the observation phase, contact with the CS+ bar was expected to be more painful than the CS- bar, $F(1;96) = 48.22$,

$p < .001$. This differential effect was caused by an increase in pain intensity expectancy regarding the CS+, $F(1;49.16) = 74.27$, $p < .001$, as no difference between baseline and observation was found for the CS- bar, $F(1;48.82) = 0.09$, ns.

Regarding expected **harmfulness** (see *Figure 8*), main effects of stimulus type and time were found, $F(1;145.60) = 15.83$, $p < .001$; $F(1;146.98) = 30.63$, $p < .001$. Additionally, a significant interaction was found between stimulus type and time, $F(1;145.60) = 27.82$, $p < .001$. Participants expected contact with the CS- bar to be more harmful than contact with the CS+ bar with respect to the baseline phase, $F(1;49) = 5.28$, $p = .03$. After watching the video, however, they expected contact with the CS+ bar to be more harmful compared to the CS- bar, $F(1;96) = 26.70$, $p < .001$. This difference was due to an increase in expected harmfulness regarding the CS+, $F(1;49.09) = 60.38$, $p < .001$, as no difference was found between the two phases with respect to the CS-, $F(1;49) = 0.38$, ns.

3.3.2 Influence of Observers' Characteristics during the Baseline and Observation Phase

Putative moderating effects of pain catastrophizing, intolerance of uncertainty, trait fear of pain, dispositional empathy (PT, FS, EC, and PD), and negative affectivity in the observer were investigated. Only statistically significant effects are reported and explained (see Table 5). **Perspective taking** (PT) moderated the relationship between stimulus type and respectively pain-related fear, $F(1; 145.54) = 8.67$, $p < .01$, pain unpleasantness, $F(1;194) = 5.56$, $p = .02$, expected pain intensity, $F(1; 145.59) = 10.18$, $p < .01$, and expected harmfulness, $F(1;145.57) = 9.40$, $p < .01$. Participants with lower PT scores reported more fear, and expected greater pain unpleasantness, pain intensity, and harmfulness regarding the CS+ compared to the CS-, $F(1; 46) = 11.44$, $p < .001$; $F(1; 46) = 8.62$, $p < .01$; $F(1; 46) = 14.99$, $p < .001$; $F(1; 46) = 7.25$, $p = .01$, respectively, whereas for individuals with higher PT, no difference between CS+ and CS- was observed, $F(1; 46) = 0.06$, ns; $F(1; 46) = 0.07$, ns; $F(1; 46) = 0.11$, ns; $F(1; 46) = 0.12$, ns, respectively. With respect to the CS+, no difference on pain-related fear ($\beta = -.09$, ns), expected pain unpleasantness ($\beta = -.03$, ns), pain intensity ($\beta = -.11$, ns), or harmfulness ($\beta = -.09$, ns) was found between participants scoring higher or lower on PT. With respect to the CS-, however, participants scoring higher on PT were more afraid of being touched by the CS- bar ($\beta = .26$, $p = .01$), and expected it to be more unpleasant ($\beta = .31$, $p < .01$), intense ($\beta = .28$, $p < .01$), and harmful ($\beta = .27$, $p = .01$), compared to participants scoring lower on PT. Moreover, **negative affectivity** (NA) was found to have a moderating influence on expected harmfulness, $F(1;145.59) = 4.17$, $p = .04$. For participants with lower NA scores, no difference between expected harmfulness regarding

the CS+ and CS- were found, $F(1; 46) = 1.77$, ns, while for participants with higher NA, more harmfulness was expected regarding the CS+ compared to the CS-, $F(1; 46) = 14.22$, $p < .001$. However, regression analyses for both stimulus types separately did not reveal any statistically significant relationship with expected harmfulness (CS+: $\beta = .17$, ns ; CS-: $\beta = -.04$, ns). There were no statistical interactions with the other variables.

3.3.3 Exposure Phase

No main effects of stimulus type and time, nor an interaction between these two variables was found for **pain-related fear, pain unpleasantness**, **pain intensity**, or **perceived harmfulness** during the exposure phase (all $p > .05$, see *Figure 8*). Only for pain unpleasantness, a main effect of baseline scores was observed, $F(1;168.20) = 11.88$, $p = .001$. Participants who expected more pain unpleasantness at the start of the experiment, also experienced more unpleasantness during exposure to the stimuli, $r = 0.18$, $p < .01$.

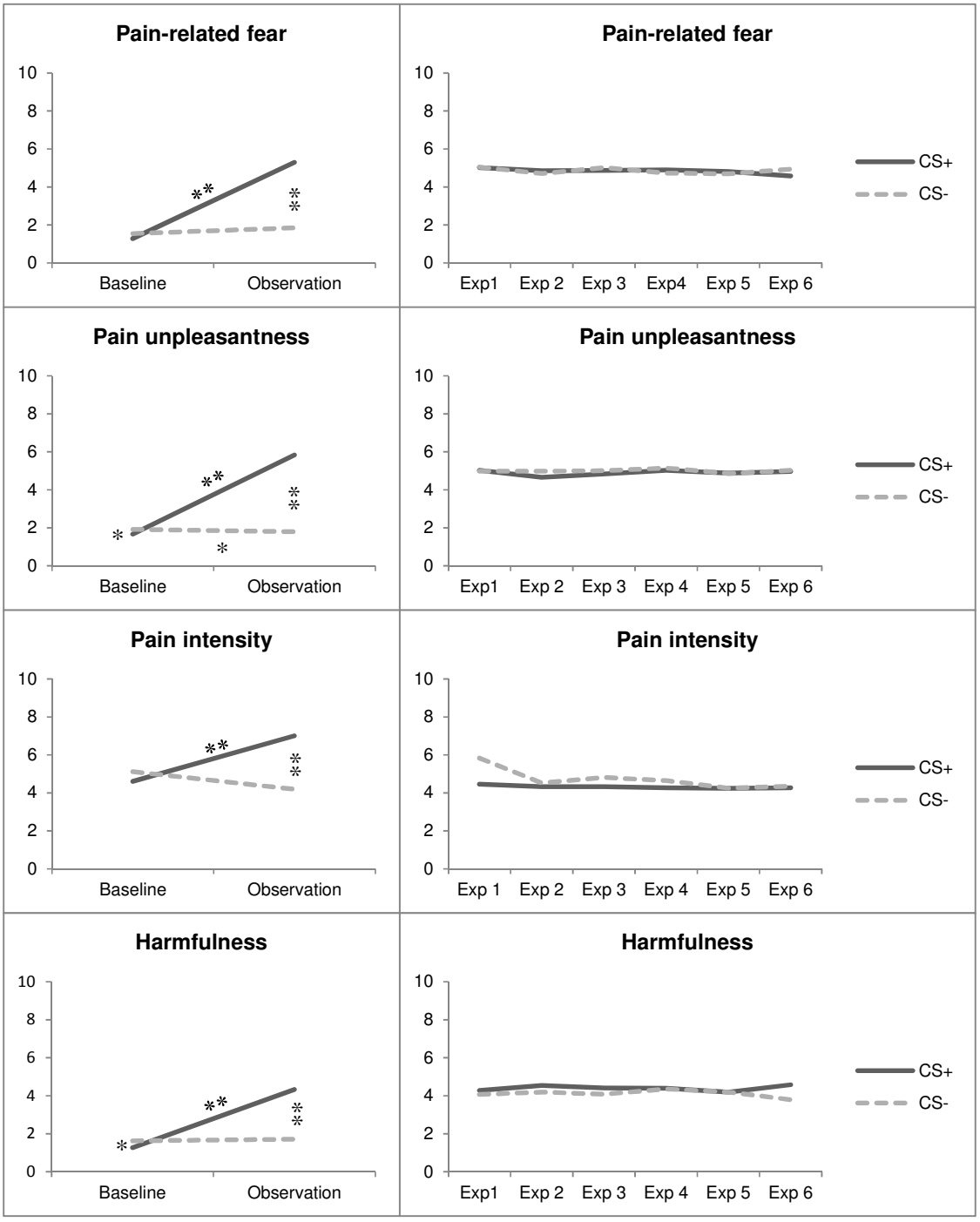


Figure 8. Self-reports: Pain-related fear, pain, and harmfulness in Experiment 1.

Exp = Exposure; * $p < .05$; ** $p < .001$.

3.3.4 Influence of Observers' Characteristics during the Exposure Phase

The same putative moderating influences were examined (see Table 5). **Personal distress** (PD) moderated the relationship between stimulus type and respectively pain-related fear, pain unpleasantness, and pain intensity, $F(1;528) = 7.48$, $p = .01$; $F(1;546.13) = 7.33$, $p = .01$; $F(1;528) = 5.57$, $p = .02$. Participants with lower PD reported more pain-related fear and pain unpleasantness with regard to the CS+ compared to the CS-, $F(1; 46) = 4.58$, $p = .04$; $F(1; 46) = 7.34$, $p < .01$, respectively, whereas participants with higher PD reported more pain-related fear and pain unpleasantness with respect to the CS- relative to the CS+ $F(1; 46) = 6.79$, $p = .01$; $F(1; 46) = 6.40$, $p = .02$, respectively. Regarding pain intensity, no differential effects were found for participants scoring higher ($F(1; 46) = 2.89$, ns) or lower ($F(1; 46) = 0.25$, ns) on PD. Regarding the CS+, no difference on pain-related fear or pain unpleasantness was found between lower and higher PD ($\beta = -.05$, ns; $\beta = -.10$, ns, respectively). However, participants with higher PD scores reported more pain after contact with the CS+ bar compared to individuals scoring lower ($\beta = .15$, $p = .01$). Regarding the CS- bar, participants with lower PD reported less fear during the exposure phase compared to participants with higher PD ($\beta = .17$, $p < .01$). No difference was found between participants scoring lower or higher on PD with respect to CS- associated pain unpleasantness or pain intensity ($\beta = .06$, ns; $\beta = -.03$, ns). Furthermore, **trait fear of pain** was found to moderate the relationship between stimulus type and respectively pain unpleasantness, pain intensity, and perceived harmfulness, $F(1;523.42) = 5.25$, $p = .02$; $F(1;517) = 5.02$, $p = .03$, $F(1;517) = 4.90$, $p = .03$. Participants with lower trait fear of pain perceived more intense pain regarding the CS- compared to the CS+ metal bar, $F(1; 45) = 10.34$, $p < .01$, but rated contact with the CS+ bar as more harmful than contact with the CS- metal bar, $F(1; 45) = 9.69$, $p < .01$. No difference in pain unpleasantness between CS+ and CS- was found for participants with lower FPQ scores, $F(1; 45) = 0.43$, ns. Participants with higher trait fear of pain reported more pain unpleasantness with respect to the CS- compared to the CS+ bar $F(1; 45) = 9.72$, $p < .01$, while for pain intensity and perceived harmfulness, no differential effects were found, $F(1; 45) = 0.01$, ns; $F(1; 45) = 0.00$, ns, respectively. Regarding the CS+, participants with lower trait fear of pain reported less pain unpleasantness and pain intensity than participants with higher FPQ scores ($\beta = -.15$, $p = .01$; $\beta = .17$, $p < .01$, respectively). No evidence for a difference on pain unpleasantness or intensity between lower and higher scorers was found with respect to the CS- bar ($\beta = .06$, ns; $\beta = .001$, ns). Regression analyses by stimulus type did not reveal any significant results with regard to perceived harmfulness (CS+: $\beta = -.08$, ns; CS-: $\beta = .09$, ns). Finally, **negative affectivity** (NA) was found to moderate the relationship between stimulus

type and pain-related fear, $F(1;528) = 4.70$, $p = .03$. No difference in pain-related fear between the CS+ and CS- bar was found for participants with higher or lower NA, $F(1; 46) = 2.73$, ns; $F(1; 46) = 1.83$, ns. Concerning the CS+, no difference was found between lower and higher scorers ($\beta = -.06$, ns), whereas for the CS-, participants with higher NA reported more pain-related fear compared to those with lower NA ($\beta = .12$, $p = .04$).

3.4 Self-reported Behavioural Avoidance Tendency (BAT)

Main effects of stimulus type and time, as well as a significant interaction between these two variables were found on self-reported **willingness to touch the bars**, $F(1;239.84) = 28.72$, $p < .001$; $F(2;241.08) = 32.94$, $p < .001$; $F(2;239.84) = 17.39$, $p < .001$, respectively (see *Figure 9*). For the CS+, willingness to touch the bar was significantly lower during the observation phase, compared to the baseline, $t(94.49) = 4.40$, $p < .001$, and exposure phase, $t(94.49) = 1.63$, $p < .001$. During exposure, participants were less willing to touch the CS+ bar compared to the baseline phase, $t(93.72) = 2.77$, $p < .01$. For the CS-, no difference was found between baseline and observation, $t(97.29) = 0.86$, ns, or between the observation and the exposure phase, $t(96.56) = 0.31$, ns. However, willingness to touch the CS- was significantly lower after exposure compared to the baseline phase, $t(97.29) = 1.17$, $p = .02$. After watching the observation video, a differential effect was found between the two stimulus types, $F(1;96) = 41.56$, $p < .001$, with participants being more willing to touch the CS- bar compared to the CS+ bar. No differences between CS+ and CS- were observed during baseline, $F(1;49) = 0.20$, ns, or during exposure, $F(1;48) = 2.33$, ns.

Perspective taking (PT) was found to moderate the relationship between stimulus type and willingness scores, $F(4;239.86) = 2.75$, $p = .03$. When conducting separate analyses for acquisition and exposure, we found that PT plays a moderating role on behavioural avoidance tendencies during acquisition (baseline x observation), $F(1;143.36) = 7.91$; $p < .01$, but not during exposure, $F(1;48) = 0.17$; ns. Participants with lower PT were more willing to touch the CS- bar relative to the CS+ bar, $F(1; 46) = 19.39$, $p < .001$, whereas for participants with higher PT scores no differential effect was found, $F(1; 46) = 0.68$, ns. However, regression analyses for each stimulus type separately during acquisition did not reveal any significant effects (CS+: $\beta = .14$, ns; CS-: $\beta = -.17$, ns) (see Table 5).

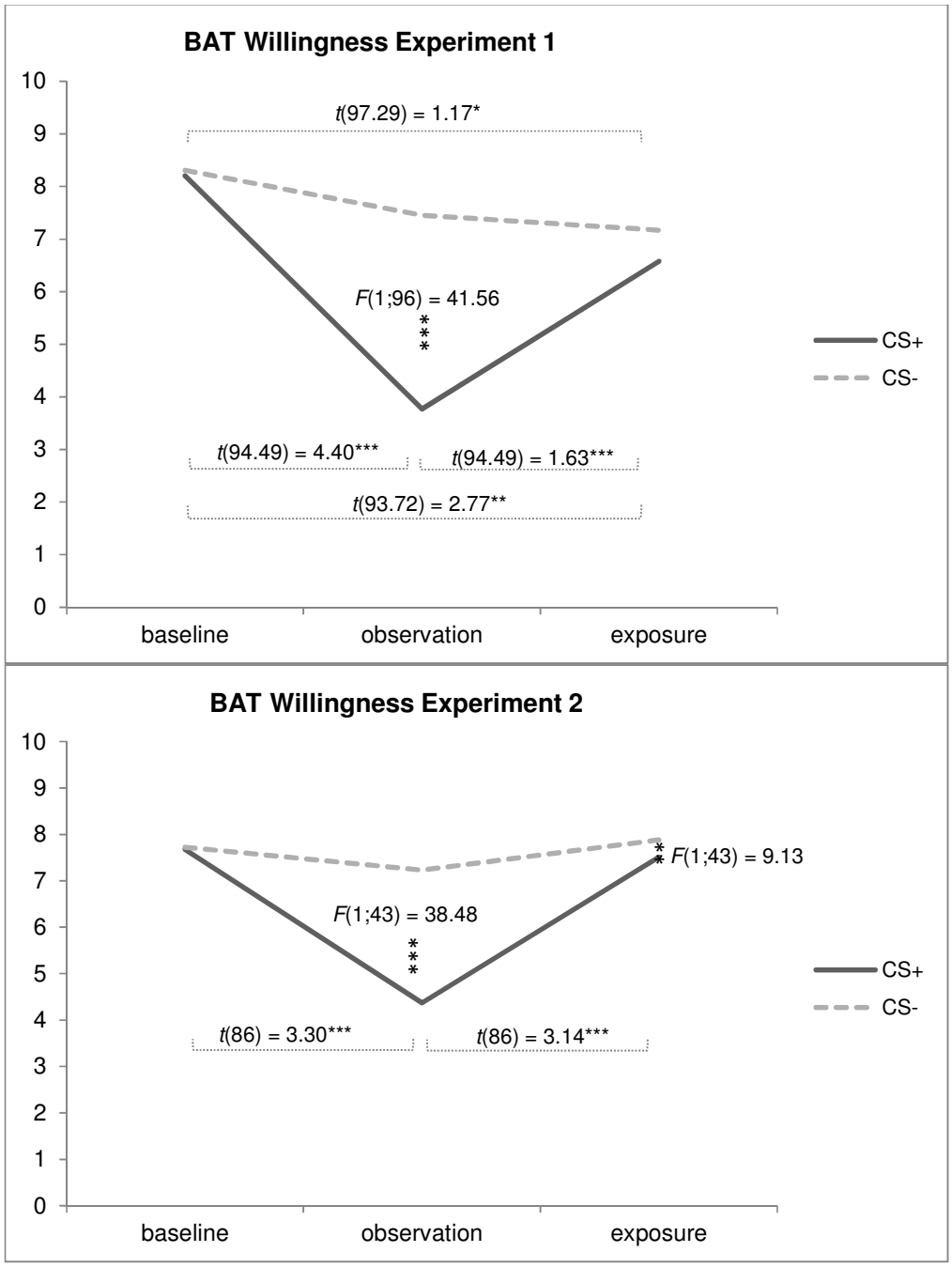


Figure 9. Self-reported behavioural avoidance tendencies: Willingness to touch the metal bars. BAT = Behavioural Avoidance Tendencies

* $p < .05$; ** $p < .01$; *** $p < .001$.

3.5 The Approach Avoidance Task (AAT)

Error rates (inaccurate response direction) were 2% in the baseline phase and 1% in the observation and exposure phase. Corresponding reaction times were excluded from further analyses. No main effects of stimulus type and time, nor an interaction between stimulus type and time was found on the compatibility scores, $F(1;234.92) = 0.94$, ns; $F(2;237.36) = 1.16$, ns; $F(2;234.92) = 1.31$, ns, respectively. None of the observers' characteristics moderated the relationship between stimulus type and the compatibility scores (all $p > .05$).

3.6 Skin Conductance Responses (SCR)

SCR during picture presentation. A main effect of time was found, $F(5;528) = 4.61$, $p < .001$, with SCR decreasing throughout the exposure phase. No main effect of stimulus type, nor an interaction between stimulus type and time was found regarding SCR to the pictures, $F(1;528) = 1.35$, ns; $F(5;528) = 0.40$, ns. Hence, no difference in physiological responding between the reactions to both pictures was observed throughout the exposure phase. None of the observers' characteristics moderated SCR to the pictures (all $p > .05$).

SCR during bar exposure. No effect of stimulus type was found during the presentations of the metal bars, $F(1;528) = 2.08$, ns. A main effect of time was found, $F(5;528) = 19.93$, $p < .001$, with SCR decreasing during the exposure phase. No interaction between stimulus type and time was found with respect to SCR, $F(5;528) = 0.31$, ns. Hence, no difference in physiological responding between the two bars was observed throughout the exposure phase, and observers' characteristics did not influence SCR (all $p > .05$).

Table 5. Moderating Influence of Observers' Characteristics.

	Experiment 1						Experiment 2					
Acquisition												
Dependent variable	Moderator	Type	β	*t*-value	Low vs. High	*F*-value	Moderator	Type	β	*t*-value	Low vs. High	*F*-value
Pain-related fear	IRI-PT	CS+	-.09	-0.87	*-SD*	**11.44*** **						
		CS-	.26	**2.67****	*+SD*	0.06						
Pain unpleasantness	IRI-PT	CS+	-.03	-0.33	*-SD*	**8.62****	IRI-FS	CS+	.06	0.54	*-SD*	**11.20****
		CS-	.31	**3.17****	*+SD*	0.07		CS-	-.24	**-2.24***	*+SD*	**36.76*** **
Pain intensity	IRI-PT	CS+	-.11	-1.05	*-SD*	**14.99*** **	IRI-FS	CS+	.16	1.51	*-SD*	**15.73*** **
		CS-	.28	**2.84****	*+SD*	0.11		CS-	-.08	-0.72	*+SD*	**52.87*** **
Harmfulness	IRI-PT	CS+	-.09	-0.88	*-SD*	**7.25***						
		CS-	.27	**2.74****	*+SD*	0.12						
	NA	CS+	.17	1.70	*-SD*	1.77						
		CS-	-.04	-0.36	*+SD*	**14.22*** **						
BAT willingness	IRI PT	CS+	.14	1.33	*-SD*	**19.39*** **						
		CS-	-.17	-1.68	*+SD*	0.68						
AAT compatibility							FPQ	CS+	.32	**3.15****	*-SD*	0.92
								CS-	.07	0.64	*+SD*	**6.59***

Exposure	Experiment 1						Experiment 2					
Dependent variable	Moderator	Type	β	*t*-value	Low vs. High	*F*-value	Moderator	Type	β	*t*-value	Low vs. High	*F*-value
Pain-related fear	IRI-PD	CS+	-.05	-0.80	*-SD*	**4.58***						
		CS-	.18	**3.01****	*+SD*	**6.79***						
	NA	CS+	-.06	-0.93	*-SD*	1.83						
		CS-	.12	**2.06***	*+SD*	2.73						
Pain unpleasantness	FPQ	CS+	-.15	**-2.53****	*-SD*	0.43						
		CS-	.06	1.07	*+SD*	**9.72****						
	IRI-PD	CS+	-.10	-1.65	*-SD*	**7.34****						
		CS-	.06	0.10	*+SD*	**6.40***						
Pain intensity	FPQ	CS+	.17	**2.92****	*-SD*	**10.34****						
		CS-	.001	0.02	*+SD*	0.01						
	IRI-PD	CS+	.15	**2.60****	*-SD*	0.25						
		CS-	-.03	-0.52	*+SD*	2.89						
Harmfulness	FPQ	CS+	-.08	-1.34	*-SD*	**9.69****	PCS	CS+	-.08	-1.35	*-SD*	0.60
		CS-	.10	1.69	*+SD*	0.00		CS-	.09	1.44	*+SD*	**4.39***
SCR pictures							IRI-FS	CS+	-.18	**-2.86****	*-SD*	**4.25***
								CS-	.06	0.94	*+SD*	2.77
							IRI-PD	CS+	.09	1.46	*-SD*	2.29
								CS-	.25	4.07	*+SD*	1.28
							NA	CS+	-.21	**-3.39****	*-SD*	2.58
								CS-	-.02	-0.34	*+SD*	1.49

Note. Acquisition = Baseline and observation phase included in analyses; BAT = behavioural avoidance tendencies; SCR = Skin Conductance responses; PCS = Pain Catastrophizing Scale; FPQ = Fear of Pain Questionnaire; NA = Negative Affectivity; IRI = Interpersonal Reactivity Index, subscales: Perspective Taking (PT), Fantasy (FS), and Personal Distress (PD), *SD* = Standard deviation, Low vs. High = Low moderator scores (mean – *SD*) vs. high moderator scores (mean + *SD*). * $p < .05$; ** $p < .01$; *** $p < .001$

4 Conclusion

In line with our hypotheses, participants reported more pain-related fear after watching the observation video with regard to the metal bar that was associated with painful expressions of the video models. Additionally, they expected contact with this metal bar to be more unpleasant, painful, and harmful in comparison to the coloured bar that was paired with the neutral facial expressions in the video. In contrast to our expectations, these changes in pain-related beliefs and cognitions did not result in avoidance behaviour with respect to the CS+, although participants reported significantly less willingness to touch the CS+ bar compared to the CS- bar after watching the video clip. No differences in pain-related beliefs and cognitions between the two bars were found during repeated exposure to the ambiguous stimuli. Nor did we found any differential effects on psychophysiological responses throughout the exposure phase. Perspective taking (PT) moderated the acquisition of pain-related beliefs and cognitions in the current experiment. Participants with lower PT scores reported significantly more fear, and expected more pain unpleasantness, pain intensity, and harmfulness with regard to the aversively conditioned stimulus (CS+) in comparison to the neutrally conditioned stimulus (CS-).

Previous research suggested that being touched by cold metal bars with a temperature of -25°C evokes an ambiguous sensation (Arntz & Claassens, 2004). We expected that in an ambiguous situation, participants are inclined to rely on information obtained from the environment, in this case the models' painful facial expressions in the video clip, to disambiguate the situation in order to interpret their own sensations. Hence, we hypothesized that watching the video would result in a difference in responding concerning pain-related fear, avoidance behaviour, and psychophysiology between the two metal bars during exposure. A possible explanation for the absence of such a difference in responding in the current experiment could be that the stimuli were considered too aversive, resulting in a ceiling effect, with participants not being able to distinguish sensations regarding both stimuli. This could also explain why self-reported avoidance tendencies after exposure were higher compared to the baseline phase for *both* CS+ and CS- bars. To exclude the possibility that the absence of different responding was merely due to the stimuli being too aversive, a follow-up experiment (Experiment 2) was conducted replicating Experiment 1, but using a higher temperature of the bars.

EXPERIMENT 2

5 Method

5.1 Participants

Participants were healthy female undergraduate students (N=43), who received either a course credit or eight Euros for their participation in the study. Exclusion criteria were chronic pain and colour blindness. All participants were Caucasian, with a mean age of 20.16 years (SD = 1.65; range 18-25). They were told that the study investigated responses to stimuli of different temperatures. Ethical approval was obtained from the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium).

5.2 Materials

Materials were the same as used in the first experiment, except for the coloured metal bars, which were cooled down in a refrigerator to approximately +8°C (instead of -25°C) in order to produce a less aversive and more ambiguous sensation.

6 Results

6.1 Sample Characteristics

Descriptive statistics, internal consistency, and Pearson inter-correlations for the different questionnaires and subscales in experiment 1 are summarized in Table 3. Mean scores were comparable to what has been reported in previous research (de Bruin, et al., 2006; De Corte, et al., 2007; Peeters, et al., 1996; Roelofs, et al., 2005; Van Damme, et al., 2002).

6.2 Contingency Awareness

All participants were aware of the contingency between the colour of the metal bars and the facial expressions of the video models (painful versus neutral). When dividing the pictures of the video models into two piles, 88.4% of the participants correctly categorised all six CS+ pictures as painful, and 11.6% erroneously categorised one CS+ picture as neutral.

6.3 Self-reported Pain-related Fear, Pain, and Harmfulness

An overview of statistical tests regarding the self-report data for both acquisition and exposure of this experiment can be found in Table 4.

6.3.1 Baseline and Observation Phase

Results were very similar to the results of Experiment 1 (see Table 4). In contrast to the findings of Experiment 1, but in line with our predictions, no differences between CS+ and CS- were observed during baseline concerning the dependent variables pain unpleasantness and perceived harmfulness. Additionally, with respect to pain unpleasantness, no difference between baseline and observation was found for the CS- bar (see *Figure 10*).

6.3.2 Influence of Observers' Characteristics during the Baseline and Observation Phase

Only statistically significant effects are reported and explained (see Table 5). **Fantasy** (FS) moderated the relationship between stimulus type and respectively pain unpleasantness, $F(1;172) = 5.05$, $p = .03$, and expected pain intensity, $F(1;129) = 5.67$, $p = .02$. Participants expected more pain unpleasantness and pain intensity regarding the CS+ compared to the CS-, and these differential effects were even stronger for participants scoring higher on FS, $F(1; 46) = 36.76$, $p < .001$; $F(1; 46) = 52.87$, $p < .001$, relative to participants with lower FS, $F(1; 46) = 11.20$, $p < .01$; $F(1; 46) = 15.73$, $p < .001$, respectively. Concerning pain unpleasantness, no difference was found between lower and higher scorers for the CS+ ($\beta = .06$, ns), whereas for the CS-, participants with lower FS expected more unpleasantness than participants with higher FS ($\beta = -.24$, $p = .03$). Concerning expected pain intensity, regression analyses for both stimulus types separately did not reveal any statistically significant results (CS+: $\beta = .16$, ns; CS-: $\beta = -.08$, ns).

6.3.3 Exposure Phase

The results of the exposure phase were comparable to the results obtained in Experiment 1 (see Table 4 and *Figure 10*). However, in Experiment 2, a main effect of time was found regarding pain-related fear, $F(5;472) = 2.73$, $p = .02$, with fear decreasing throughout the exposure phase.

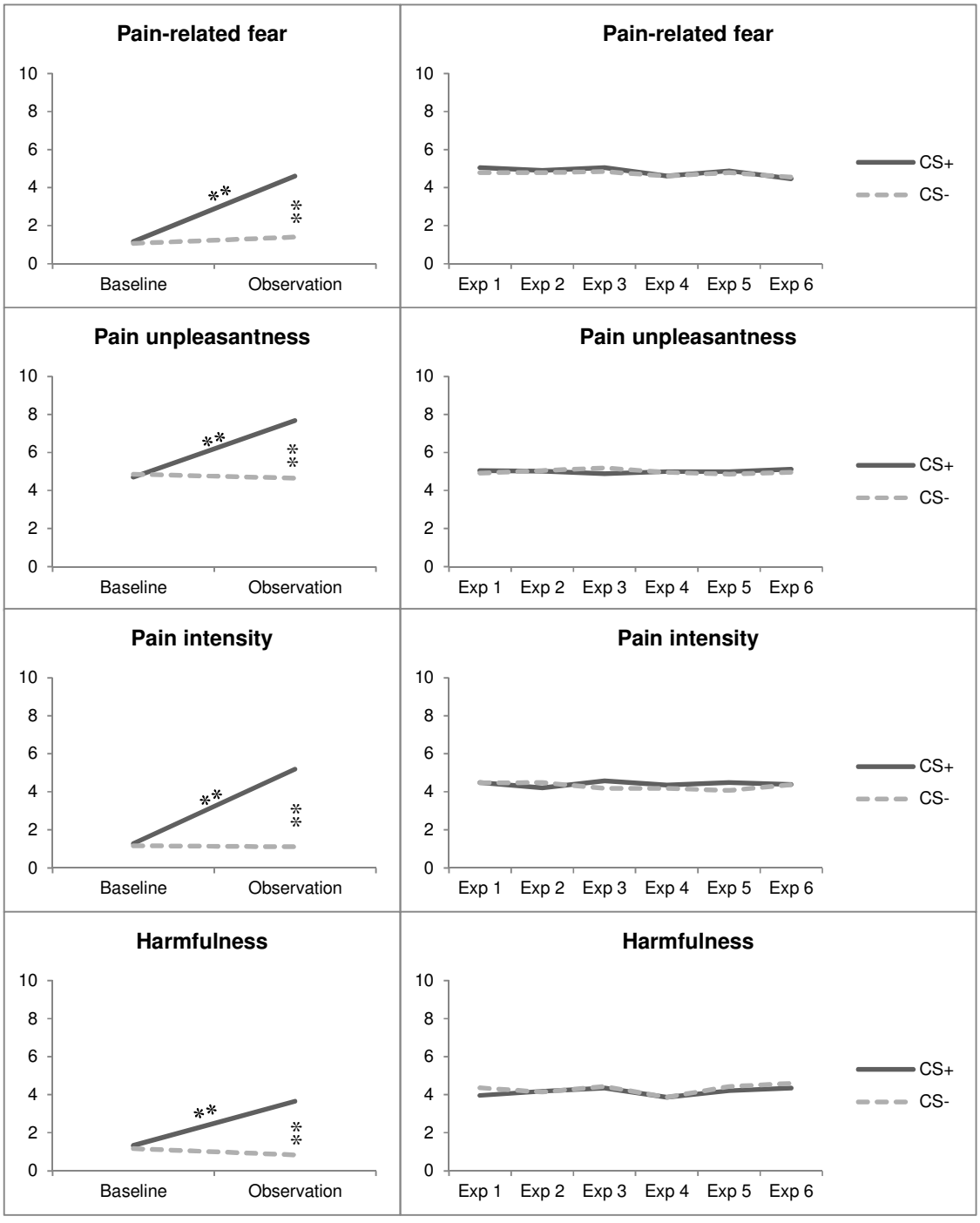


Figure 10. Self-reports: Pain-related fear, pain, and harmfulness in Experiment 2.

Exp = Exposure; * $p < .05$; ** $p < .001$.

6.3.4 Influence of Observers' Characteristics during the Exposure Phase

Only statistically significant effects are reported (see Table 5). **Pain catastrophizing** (PCS) moderated the relationship between stimulus type and perceived harmfulness, $F(1;516) = 4.02$, $p = .04$. High pain catastrophizers perceived the CS- as more harmful than the CS+, $F(1; 46) = 4.39$, $p = .04$, while for low pain catastrophizers, no differential effects were found, $F(1; 46) = 0.60$, ns. Regression analyses by stimulus type did not reveal any significant differences between participants with lower and higher scores on the PCS (CS+: $\beta = -.08$, ns; CS-: $\beta = .09$, ns).

6.4 Self-reported Behavioural Avoidance Tendency

Results of the self-reports concerning behavioural avoidance tendencies were comparable to the results of Experiment 1 (see *Figure 9*). In contrast to the first experiment, willingness to touch the CS+ bar after exposure did not differ from baseline level, $t(86) = 0.16$, ns , although willingness to touch the CS+ bar was still significantly lower as compared to the CS- bar, $F(1;43) = 9.13$, $p = .004$. No moderating effects were observed.

6.5 The Approach Avoidance Task (AAT)

Error rates (inaccurate response direction) were 1% in all three phases, and corresponding responses were excluded from further analyses. No main effect of stimulus type or time, nor an interaction between these two variables was found on the compatibility scores, $F(1;215) = 1.69$, ns; $F(2;215) = 1.03$, ns; $F(2;215) = 1.00$, ns, respectively. This means that overall, no differences between stimulus types were found over time.

Trait fear of pain (FPQ) moderated the relationship between stimulus type and compatibility scores, $F(4;215) = 2.62$, $p = .04$. When conducting separate analyses for acquisition and exposure, we found that trait fear of pain played a moderating role on AAT compatibility scores during the acquisition phase (baseline x observation), $F(1;129) = 5.51$; $p = .02$, but not during the exposure phase, $F(1;43) = 0.00$; ns. Participants with higher trait fear of pain showed more approach tendencies regarding the CS+ relative to the CS- pictures during acquisition, $F(1; 45) = 6.59$, $p = .01$, while for participants scoring lower on the FPQ, no differential effects were found, $F(1; 45) = 0.92$, ns. Regression analyses for each stimulus type separately during acquisition revealed that participants scoring lower on the FPQ showed relatively more avoidance behaviour with regard to the CS+, whereas participants scoring higher on the FPQ displayed relatively more approach tendencies concerning the CS+ metal bar (CS+: $\beta = .32$, $p < .01$). With regard to the CS- bar, no differences were found between lower and higher scorers on the FPQ (CS-: $\beta = .07$, ns) (see Table 5).

6.6 Skin Conductance Response (SCR)

SCR during picture presentation. A main effect of time was found, $F(5;473) = 2.31$, $p = .04$, with SCR decreasing over time. No main effect of stimulus type, nor an interaction between stimulus type and time was found with respect to SCR, $F(1;473) = 0.15$, ns; $F(5;473) = 0.60$, ns. Although physiological reactions diminished, no difference in psychophysiological responses was found between the CS+ and CS- bar.

Statistically significant moderation effects are notified in Table 5. **Fantasy** (FS), **personal distress** (PD), and **negative affectivity** (NA) had a moderating influence on SCR to the pictures of the bars, $F(1;473) = 12.37$, $p < .001$, $F(1;473) = 6.38$, $p = .01$, $F(1;473) = 7.18$, $p = .01$, respectively. Participants with lower FS showed stronger physiological responses when watching the CS+ pictures compared to the CS- pictures in anticipation of exposure to the bars, $F(1; 46) = 4.25$, $p = .046$, while no differential effects were found for participants with higher FS, $F(1; 46) = 2.77$, ns. For PD and NA, no differential effects were found for participants scoring lower, $F(1; 46) = 2.29$, ns; $F(1; 46) = 2.58$, ns, or higher, $F(1; 46) = 1.28$, ns; $F(1; 46) = 1.49$, ns, on these personality traits. Regarding the CS+ bar, participants scoring lower on FS, or NA showed stronger physiological reactions compared to participants scoring higher on these questionnaires ($\beta = -.18$, $p = .01$; $\beta = -.21$, $p = .001$, respectively). With respect to PD, no difference was found between lower and higher scorers concerning the CS+ ($\beta = .09$, ns). For the CS- bar, participants scoring higher on PD displayed stronger psychophysiological reactivity than participants scoring lower ($\beta = .25$, $p < .001$), while for FS and NA, no difference in physiological responding was found ($\beta = .06$, ns; $\beta = -.02$, ns).

SCR during bar exposure. A main effect of stimulus type was found during exposure to the metal bars, $F(1;473) = 4.35$, $p = .04$. As expected, participants showed more SCR with regard to the CS+ compared to the CS- bar. A main effect of time was found, $F(5;473) = 12.14$, $p < .001$, with SCR decreasing throughout the exposure phase. No interaction between stimulus type and time was found with respect to SCR, $F(5;473) = 1.07$, ns , indicating that no difference in the reduction of the physiological responses was found between the CS+ and CS- bar throughout the exposure phase. None of the investigated observers' characteristics was found to have a moderating influence on SCR to the presentation of the bars (all $p > .05$).

7 Discussion

The main objective of the current study was to examine observational acquisition of pain-related fear and the subsequent extinction through repeated first-hand exposure to the feared stimuli, focusing on (1) self-reported pain-related fear, pain, and harmfulness, (2)

psychophysiological responses, and (3) behavioural tendencies (1968). A differential fear conditioning procedure was used, showing video models displaying either a painful (CS+ colour) or a neutral (CS- colour) facial expression when exposed to one of two coloured metal bars (observation phase). Afterwards, both metal bars with equal temperatures (Experiment 1: -25°C; Experiment 2: +8°C) were repeatedly presented to participants' necks (exposure phase).

In the current study, evidence was found for indirect acquisition of pain-related fear, corroborating earlier findings (Helsen, et al., 2011). After watching the observation video, participants reported more pain-related fear with regard to the coloured bar that was previously associated with models' painful expressions. They also expected contact with this metal bar to be more unpleasant, painful, and harmful in comparison to the metal bar that was paired with the models' neutral facial expressions. Moreover, participants were less willing to touch the CS+ bar after observation of the models, compared to the CS- bar. Surprisingly, in the first experiment, participants expected more unpleasantness and harmfulness with respect to the CS- bar compared to the CS+ bar prior to the conditioning procedure. The reason for this is not clear. However, after watching the video, a differential effect in the opposite direction was found, suggesting that the meaning of the bars was influenced in the expected direction.

The changes in pain-related beliefs did, however, not result in avoidance behaviour regarding the CS+. These results differ from previous research, in which evidence was found for an observational fear learning effect on avoidance behaviour (Gerull & Rapee, 2002), pain threshold (Craig, 1986; Goodman & McGrath, 2003), and pain tolerance (Turkat & Guise, 1983). One possible explanation might be that avoidance behaviour in our study was measured in an implicit way. In previous fear research (Egliston & Rapee, 2007; Koch, O'Neill, Sawchuk, & Connolly, 2002), avoidance behaviour was measured using a behavioural approach-avoidance paradigm, in which participants gradually approached the feared stimulus. It was not possible to use a similar task in the current study, because touching the bars after watching the video would have influenced participants' experiences during exposure. A second direct way of measuring avoidance behaviour is to compare latency time before contact with the feared and non-feared stimulus (Askew & Field, 2007; Helsen, et al., 2011). However, participants in this study could not control the exact moment of exposure to the bars. In this study, we only focused on avoidance behaviour. It might have been interesting to examine participants' communicative pain expressions during actual exposure to the metal bars (PrKachin, 1986). Another reason for the absence of a behavioural effect,

could be the (lack of) importance of the stimuli. One might expect that personal relevance plays an important role (Goubert, et al., 2011; Hermann, 2007). The laboratory setting might not have been threatening for the healthy participants, whereas for pain patients, impending pain is probably more salient, resulting more easily in behavioural changes. Future research could further investigate under which conditions these changes occur. The nature of the relationship between model and observer might influence the strength of the learning effect (Goubert, et al., 2011). Although observational learning effects are not restricted to observing intimate pain models, family or 'in-group' members are supposed to have a larger influence than strangers (Braaksma, Rijlaarsdam, & van den Bergh, 2002; Platow, Grace, Wilson, Burton, & Wilson, 2008). Nevertheless, both the models and the participants in our study were young females. The models were told to be students that participated earlier in the same study, hence belonging to the same in-group.

No differences between both bars were observed regarding pain-related fear, pain, and perceived harmfulness during repeated exposure. Nor did we find a reduction in these measures throughout this phase, although a small overall decrease in pain-related fear was found in the second experiment. The absence of a difference in fear might be due to generalisation of the fear to the CS-, as both coloured bars share several features (Meulders & Vlaeyen, in press). Although, strictly speaking, no direct comparison between phases is possible, since during acquisition expectations were measured, whereas during exposure actual experiences are investigated, it seems that not the negative appraisals regarding the CS+ are diminished after exposure, but rather the aversive beliefs concerning the CS- are enhanced.

Results regarding the self-reported avoidance tendencies after exposure were not unequivocal in our two experiments. In the first experiment, no difference between the two stimuli was found, although willingness to touch both bars was lower compared to the start of the experiment. In the second experiment, participants were more willing to touch the CS- bar than the CS+ bar, and willingness did not differ from the baseline. These findings might indicate that a temperature of -25°C may have provoked a sensation that was too aversive, and that the bars in the second experiment were indeed experienced as more ambiguous. One could also argue that these results provide evidence for the persistence of fear until the end of the experiment.

In contrast to earlier findings regarding fear in general (Kelly & Forsyth, 2007a, 2007b; Olsson, et al., 2007; Olsson & Phelps, 2004), no differences in SCR in anticipation of direct contact with the bars were found in either experiment. However, overall skin

conductance responses decreased throughout repeated exposures, which is in line with previous research (1978), showing that physiological responses attenuated easily when stimuli are fear-irrelevant. Only in the second experiment evidence was found for a difference in psychophysiological responding after contact with both metal bars. This difference persisted throughout exposure. It is, however, difficult to compare this latter finding with previous research, as in other paradigms no real shocks (Olsson, et al., 2007; Olsson & Phelps, 2004) or enriched CO_2 air (Kelly & Forsyth, 2007a) were administered during extinction.

Examining putative moderators is essential in the identification of individuals who are at risk of developing pain problems. In contrast to our expectations, in this study, none of the investigated moderators had a consistent influence on any dependent variable across both experiments. However, some trends can be observed. In the first experiment, participants with lower perspective taking (PT) reported significantly more fear, and expected more pain unpleasantness, intensity, and harm regarding the CS+ compared to the CS-. In the second experiment, participants with higher fantasy (FS) showed a larger differential effect concerning pain unpleasantness and intensity expectations relative to participants with lower FS. Hence, dispositional empathy may be an important factor in the acquisition of pain-related beliefs. This accords with earlier studies, showing that neural regions linked to empathy are also active during observational fear learning (Olsson, et al., 2007), and that observers with higher empathy are more responsive to a placebo analgesia intervention after witnessing successful pain treatment (Colloca & Benedetti, 2009). However, more research needs to be undertaken before the association between empathy and observational pain-related fear acquisition is more clearly understood. In contrast to our expectations, participants scoring higher on trait fear of pain in Experiment 2 displayed relatively more approach tendencies concerning the CS+ bar after watching the video clip than those with lower scores. The reason for this is not clear; future studies should replicate this in order to ascertain whether specific subgroups are particularly susceptible to observational learning of pain-related fear.

The results of this study may yield some implications for clinical pain management. Since pain-related fear can be more disabling than the pain itself (Crombez, et al., 1999), many chronic pain patients may benefit from treatment targeting pain-related fear. It might also be appropriate to implement knowledge concerning observational learning in acute pain situations, because early prevention interventions concerning pain-related fear may avert transition from acute to chronic pain. For instance, health care professionals should be aware of their attitudes regarding pain and pain-related fear (Darlow, et al., 2012; Linton, Vlaeyen, & Ostelo, 2002), as patients might take over these attitudes through observation and verbal

instructions. Additionally, meeting recovered pain patients suffering from similar injuries might reduce pain-related fear acquisition. Furthermore, family members of pain patients can be involved in psycho-educational treatment sessions explaining observational learning processes and possible maintaining factors concerning pain, since these individuals often observe their family member in pain, which may increase their own vulnerability for pain, avoidance and disability later in life (Vlaeyen & Crombez, 1999).

There are a few limitations to this study, which need to be considered. First, participants were healthy young females, restricting external validity. Future research is needed to examine whether our findings generalize to male samples and individuals suffering from acute or chronic pain. Pain information may be transmitted in a sex-dependent manner (Hermann, 2007). Consequently, observers might learn more easily from same-gendered models (Goubert, et al., 2011). In the current study, we have only focused on females, because women are more prone to develop chronic pain, and are also known to report having more pain models, who are mostly female (Koutantji, Pearce, & Oakley, 1998). Second, skin conductance was used as a psychophysiological measure. Startle response (EMG) might be a better measure to use in future experiments because it is more specifically related to fear, whereas skin conductance is a measure for general arousal (Vrana, Spence, & Lang, 1988). In addition, it has been used successfully in experimental fear of pain studies (Meulders, et al., 2011). Despite these limitations, the findings of this study provide evidence that direct experience is not a necessary feature for the acquisition of pain-related beliefs and cognitions.

CHAPTER IV:
Observational Learning and Pain-related Fear: Exploring Contingency Learning in an Experimental Study using Warm Water Immersion

Abstract

The current study investigated observational learning of pain-related fear, and subsequent extinction after first-hand exposure to the feared stimulus. Moreover, we examined whether certain observers' characteristics facilitated the observational learning effects. Finally, the specific contingencies that are learned when observing others in pain were explored. A differential fear conditioning paradigm was used, showing video models displaying either a painful (CS+ colour) or a neutral (CS- colour) facial expression in the presence of a coloured warm water task (WWT; observation phase). In one condition (open WWT cover), the models' hand immersed the coloured liquid, while in the other condition (closed WWT cover), no contact was displayed between the model and the liquid. During the exposure phase, participants subsequently immersed their own hand into each WWT with equal temperatures. Results revealed successful acquisition of self-reported pain-related fear, associated with CS- task preference and CS+ avoidance in a stimulus response categorisation task, but not with immersion latency. Participants with higher levels of pain catastrophizing, intolerance of uncertainty, trait fear of pain, or dispositional empathy were more prone to develop pain-related fear through observation. Pain-related fear extinguished quickly after direct exposure to both WWT. In contrast to our expectations, contingencies between the colour of the WWT and either the painful facial expressions or the assumed properties of the coloured liquid were learned in both conditions. Clinical implications and limitations of the current study are discussed, providing avenues for future research in observational learning of pain-related fear.

Keywords: Observational learning, pain-related fear, contingency learning

1 Introduction

Chronic pain and associated interference in daily life is acknowledged to be influenced by a multitude of biological, psychological, and social factors (Gatchel, et al., 2007). An important psychological factor in the development as well as the persistence of chronic pain is pain-related fear (Leeuw, et al., 2007; Vlaeyen & Linton, 2012), which is an (often excessive) fear, that arises in the presence or the anticipation of a pain-eliciting situation (Kori, et al., 1990). Fear can develop after the formation and evaluation of propositions about relations between stimuli or events (De Houwer, 2009; Mitchell, et al., 2009), e.g., stimulus A (movement X) might *cause* stimulus B (pain). Pain-related fear propositions can develop in at least three different ways (Olsson & Phelps, 2004): (1) through direct experience, (2) by verbal instructions, and (3) via observation. Common to these pathways is that a formerly neutral stimulus acquires threat value after being associated with an aversive stimulus, often resulting in avoidance behaviour.

Recently, researchers started studying the observational learning pathway to pain-related fear (Goubert, et al., 2011; Helsen, et al., 2011), which can be described as *'changes in patterns of behaviour that are a consequence of observing others' behaviours'* (Bandura, 1986). In a previous study using coloured cold pressor tasks (CPT), evidence was found for the acquisition of self-reported pain-related fear (Helsen, et al., 2011). However, these reports did not result in changes in avoidance behaviour, which is, according to Bandura (Bandura, 1986), a necessary condition for observational learning. Moreover, findings of previous studies may also be explained as merely the result of classical conditioning with a social stimulus (i.e., the painful facial expression of a video model). In order to find evidence for observational learning stricto sensu, the association between the colour of the liquid and the properties of the liquid should be inferred from the models' (painful) facial expressions.

Accordingly, the main objective of the current study was to examine observational learning of pain-related fear, and subsequent extinction after first-hand exposure to the feared stimulus. Avoidance behaviour was measured more elaborately, using an indirect reaction time task (Stimulus Response Categorisation task (SRC)), a forced choice task (warm water task (WWT) preference), and a direct reaction time measure (immersion latency). Furthermore, we were interested in the specific contingencies that are learned when observing others in pain to better understand the observational nature of the learning processes. Finally, we wanted to explore whether individual differences in observers' pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy facilitate learning effects. Coloured warm water tasks (WWT) were used in a differential fear

conditioning paradigm with healthy participants. One colour (CS+) was associated with painful facial expressions of video models, whereas the other colour (CS-) was paired with neutral expressions (observation phase). We expected the CS+ WWT to elicit stronger fear responses relative to the CS- WWT. Afterwards, participants subsequently immersed their own hands into each WWT, with equal temperatures (exposure phase). Differential effects were hypothesized to diminish after first-hand exposure to the WWT. By using two types of WWT (one with a closed WWT cover, the other with an opening in the WWT cover), we intended to manipulate the contingencies that were learned during observation. We expected participants in the open cover condition to show stronger learning effects as the causal relationship between the painful facial expression and warm water immersion was more obvious.

2 Method

2.1 Participants

Sixty healthy female undergraduate students, who received either a course credit or 8 Euro, participated in the current experiment. Exclusion criteria included colour-blindness, and the report of chronic pain. With the exception of one participant of African and one of Asian origin, all participants were Caucasian. The mean age was 19.88 (*SD* = 2.68; range 17 - 33), with one person (1.67%) being left-handed. None of the participants had consumed analgesic pain medication on the day of testing. Participants signed the informed consent form, explaining the course of the experiment and informing participants that they could withdraw from the study at any time for any reason. Ethical approval was provided by the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium).

2.2 Apparatus and materials

2.2.1 Warm water immersion tasks

Warm water tasks (WWT) were performed using two identical Plexiglas boxes (Julabo®), each containing an electric immersion cooler, type FT200, and a bath circulator, type ED-19A. Both immersion baths, measuring 18cm high, 27cm wide, and 39cm long, were placed upon a trolley adjustable in height to provide comfortable access to the box. A registration button was placed on the bottom of each box to record immersion latency and

early withdrawal. The temperature of the water was preserved at 45 °C (± 0.03 °C) in order to induce an ambiguous, slightly unpleasant sensation. This temperature, which lies around the thermal nociceptive threshold (LaMotte, Lundberg, & Torebjörk, 1992), is shown to be harmless for its chosen duration (Moritz & Henriques, 1947). Previous studies have indicated that temperatures of 47 °C and more are perceived as 'painful' (Bushnell, et al., 1999; Rainville, Duncan, Price, Carrier, & Bushnell, 1997). A third water tank, type TW20 Julabo, was used for immersion at room temperature (21°C ± 0.5 °C). Before each WWT, participants were requested to hold their hand in this tank for 60 seconds to guarantee they all started with an identical skin temperature.

2.2.2 Unconditioned stimuli

Painful facial expressions were used as aversive unconditioned stimuli (US); while neutral faces acted as neutral stimuli. Video material from a cold pressor (CPT) study at the Maastricht University (Netherlands) displaying human facial expressions was used with participants' consent (Vlaeyen, et al., 2009). The Child Facial Coding System (CFCS) (Chambers, et al., 1996), a coding system applicable in adults as well, and derived from the Facial Action Coding System (Ekman & Rosenberg, 1997), was used to code the facial expressions of that study. For the current experiment, eight female participants of the previous CPT study – four with the highest and four with the lowest facial pain expression scores – were selected to create different video clips with a duration of approximately 40 seconds each. All video models were healthy undergraduate students of the Maastricht University, performing a CPT at 2°C. This temperature was cold enough to induce pain expressions. Mean age of the models was 24.5 years old for both the CS+ and CS- condition (CS+ range 21-31; CS- range 23-26).

2.2.3 Conditioned stimuli

The liquid in the two Plexiglas boxes was water coloured differently using Ecoline, which is a safe and harmless colorant (Creall®; orange, 1371003; pink, 1371017). One colour (CS+) was paired with the painful facial expressions of the video models, while the other colour (CS-) was associated with the neutral facial expressions (counterbalanced).

2.2.4 Observation video clips

On the left side of the computer screen a painful or neutral facial expression of a video model was displayed, while simultaneously on the right side a video fragment of a coloured Plexiglas box was presented. By means of a fog machine (used in professional entertainment

applications), artificial mist was coming out of the box that was presented together with the painful facial expressions in order to increase the threat value of the aversively conditioned stimulus (CS+). Four different versions of the observation video were made, depending on the colour of the CS+ (orange vs. pink), and the configuration of the Plexiglas box (closed vs. open cover). In the condition with the closed covers on the Plexiglas boxes, participants were led to believe that no contact was possible between the model and the coloured water. Consequently, the cause of the painful facial expressions must have been attributed to something different than the properties of the water. In the other condition, with the open covers, participants saw a hand immersing the coloured water, while the arm of the video models moved synchronously out of the left frame. In this condition, participants were assumed to attribute the facial expressions to the properties of the water. One random order of the facial expression fragments was determined for all versions of the video, with a maximum of two consecutive trials of the same type (CS+ vs. CS-). The corresponding frames on the right were different for the four conditions.

2.3 Measures

2.3.1 Contingency awareness

Two different types of contingencies can be learned in the current experiment. *First*, a directly experienced association can be learned between the colour of the water (CS) and the painful facial expressions of the video models (primary US). This way, the colour of the water becomes a predictor for the facial expression of the model. *Second*, an indirectly experienced contingency can be obtained between the colour of the water (CS) and the assumed properties of the water, namely being warm or painful (secondary US). In order to find evidence for observational learning, the indirectly experienced relationship should have been learned.

US expectancy. According to Lovibond and Shanks (2002), awareness of the contingency between conditioned (CS) and unconditioned stimuli (US) should be measured using concurrent US expectancy ratings. Immediately before each video fragment, participants were asked to which degree (0 = *not at all*; 10 = *very certain*) they expected to see a painful facial expression in the following video clip.

Categorisation task. In order to investigate the nature of the contingencies that were learned more thoroughly, participants performed a categorisation task at the end of the experiment, showing a black-and-white picture of the facial expression of the video model in each video clip. They were requested to divide these pictures into two categories: One

category was associated with the pink, the other with the orange WWT. Afterwards, they were asked which criterion they had used to categorise the pictures.

2.3.2 Self-reports

Baseline fear. At the start of the experiment, a picture of both coloured Plexiglas boxes was shown. Participants were asked to rate their fear with regard to both boxes on a numerical rating scale from 0 to 10 (*not at all; very much*), being unaware of the upcoming immersions of their hands into the coloured liquids. *Pain-related fear, pain, and harmfulness.* Four numerical rating scales regarding assumed properties of being in contact with the coloured water were presented. The scales measured pain-related fear, pain intensity, perceived harmfulness, and pain unpleasantness. The former three ranged from 0 to 10 (*not at all; very much*), the latter from -5 to 5 (*very unpleasant; very pleasant*). In order to preserve consistency, the pain unpleasantness scale was recoded afterwards (0 = *very pleasant*; 10 = *very unpleasant*). During the observation phase and before each immersion, these scales referred to participants' expectations, while after each immersion, the scales were related to actual experiences.

Behavioural avoidance tendency. Self-reported behavioural avoidance tendencies (BAT) were measured after watching the video clips. Participants rated on a numerical rating scale ranging from 0 to 10 (*not at all; very much*) their willingness to immerse their own hand into each WWT.

State catastrophizing about pain. After observation of the video models, as well as immediately before each actual immersion, participants evaluated their level of catastrophizing at that specific time on a scale from 0 to 10 (*not at all; very much*). The three state catastrophizing scales questioned the level of rumination about the possible pain they expected, the possibility that something bad could happen, and the feeling that one could not endure the pain during the immersions.

2.3.3 Avoidance behaviour

Stimulus response compatibility task. During the baseline phase as well as after watching the observation video clips, avoidance behaviour was measured indirectly using a stimulus response compatibility task (SRC). This categorisation task is based on the compatibility principle, meaning that, although the content of the presented stimuli is irrelevant for the task instruction, participants' reaction time (RT) is affected by the compatibility between the response and the valence of the stimuli (De Houwer, 2003). Stimuli

consisted of two horizontal and two vertical pictures of both the pink and the orange WWT. Each picture was presented four times, resulting in 32 trials, with the restriction that maximum two consecutive trials could have the same orientation (horizontal vs. vertical), and presented the same coloured WWT (orange vs. pink). In the open cover condition, pictures showed a WWT with an opening in the cover, while in the closed cover condition, photos of a WWT with a closed cover were presented. In each trial, a manikin was presented above or below the presented picture (counterbalanced). Participants were instructed to move the manikin away from a horizontally oriented picture, and to move the manikin towards a vertically oriented picture, or vice versa (counterbalanced), using the arrows on the keyboard. They were requested to do this as fast and accurately as possible. During the baseline phase, a practice phase preceded the SRC, randomly showing four horizontally and four vertically oriented pictures of the room temperature immersion tank. Only during the practice trials, participants received feedback about the accuracy of their responses.

WWT preference. At the end of the observation phase, participants were asked in which liquid they preferred to immerse their hand into. Avoidance of the CS+ task that was associated with the painful facial expressions of the video models was considered a proxy of pain-related fear.

Immersion latency. Time that elapsed between the appearance of the instruction ('Immerse your hand when you feel ready') and press of the registration button on the bottom of the WWT was registered (Spruyt, et al., 2010). Longer immersion latency time was considered a proxy of avoidance behaviour. Possible early withdrawals were also registered.

2.3.4 Mediation

By using an open versus closed cover condition, we intended to manipulate the contingencies that were learned while watching the observation video clips. In the open cover condition, participants observed direct contact between the hand of the video model and the coloured liquid. In this condition, participants were assumed to learn both types of contingencies (see *2.3.1 Contingency awareness*). In the closed cover condition, no contact between the model and the coloured water was displayed, which was also explicitly emphasized by the experimenter. Consequently, the cause of the painful facial expressions should be attributed to something different than the properties of the water.

Participants were asked to evaluate six mediation questions suggesting possible causes of the painful facial expressions of the video models on numerical rating scales ranging from 0 to 10 (*not at all; very much*). Proposed causes were the colour of the liquid, a tingling odour

in the room, the temperature of the liquid, contact of the hand with the liquid, a mechanical device stimulating the phalanx of the video model's index, and the aversiveness of the facial expressions.

2.3.5 Observer's characteristics

2.3.5.1 Pain Catastrophizing

Catastrophic thinking about pain was assessed by the 13-item Pain Catastrophizing Scale (PCS) (Sullivan, et al., 1995; Van Damme, et al., 2002). Participants were inquired to reflect on past painful situations, such as headaches, tooth pain, joint or muscle pain, indicating the degree to which they experienced catastrophizing thoughts and feelings on a 5-point scale, ranging from 0 *(not at all)* to 4 *(always).* Although three subscales (Rumination, Magnification, and Helplessness) can be discriminated, only the total score (range 0-52) was of interest in the current study, with higher scores representing stronger pain catastrophizing. This self-report measure has been shown to be reliable and valid in both clinical and non-clinical populations (Crombez, et al., 1998; Crombez, et al., 1999; Van Damme, et al., 2002), being consistent with the reliability found in the current study (Cronbach's alpha = .82).

2.3.5.2 Trait Fear of Pain

The Fear of Pain Questionnaire (FPQ) (McNeil & Rainwater, 1998; Roelofs, et al., 2005) comprises 31 items describing specific painful situations, as fear is assumed to be specific to particular stimuli and contexts (McNeil & Rainwater, 1998). Participants were asked to report on a 5-point scale (A = *no fear at all*; E = *extremely fearful*) the degree of fear they experienced or expected to experience with regard to the pain in the described situations. Higher scores denoted higher trait fear of pain. Three subscales (Severe pain, Minor pain, and Medical pain) can be distinguished, but in the current experiment only the sum score was used (range 31-155). Reliability of the questionnaire in this study was high (Cronbach's alpha = .88), which is in line with previous research showing good internal consistency and test-retest reliability in clinical as well as non-clinical populations (McNeil & Rainwater, 1998; Osman, et al., 2002; Sperry-Clark, et al., 1999).

2.3.5.3 Trait Negative Affectivity

Negative affectivity was evaluated by the Trait version of the Positive And Negative Affect Schedule (PANAS) (Peeters, et al., 1996; Watson, et al., 1988). This self-report measure consists of two 10-item subscales: Positive affectivity (PA), and Negative affectivity

(NA). Participants were requested to report the degree to which they experienced every presented emotion in daily life on a 5-point scale (*very little*; *very often*). The sum of the ratings on the negative emotions yields the total score for Negative affectivity (range 10-50). Internal consistency of this subscale was good (Cronbach's alpha = .78), which is comparable to previous research (Peeters, et al., 1996; Watson, et al., 1988).

2.3.5.4 Intolerance of Uncertainty

The Intolerance of Uncertainty Scale (IUS) (de Bruin, et al., 2006; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994) assesses intolerance of uncertainty, a cognitive process associated with worry (Dugas, Gosselin, & Ladouceur, 2001). Participants were inquired to indicate to what extent they agreed with 27 propositions concerning uncertain or ambiguous situations (1 = *not at all characteristic of me*; 5 = *entirely characteristic of me*). This questionnaire is mostly summed as a total score, with higher scores representing greater intolerance of uncertainty (Roemer, 2001). The IUS was found to be reliable (Cronbach's alpha = .80), which is comparable to previous studies (de Bruin, et al., 2006).

2.3.5.5 Dispositional Empathy

The Interpersonal Reactivity Index (IRI) (Davis, 1980; Davis, 1983; De Corte, et al., 2007) is used to measure dispositional empathic tendencies. It consists of 28 statements about thoughts and feelings one can experience in certain situations. Participants were asked to indicate to what extent the assertions described them, on a 5-point scale (*A = does not describe me well; E = describes me very well*). The IRI comprises four subscales: Perspective Taking (PT; i.e. the tendency to adopt another's psychological point of view), Fantasy (FS; i.e. the tendency to identify strongly with the feelings and actions of fictitious characters), Empathic Concern (EC; i.e. the tendency to experience feelings of warmth, sympathy, and concern for unfortunate others), and Personal Distress (PD; i.e. the tendency to experience feelings of discomfort and concern when witnessing others' distress) (Davis, 1983). All four subscales have satisfactory internal consistency (Cronbach's α = 0.80, 0.81, 0.61, 0.64, respectively), corroborating earlier findings (De Corte, et al., 2007).

2.4 Procedure

In this within-subject design, the colour of the CS+ (orange vs. pink), the configuration of the WWT (closed vs. open cover), the SRC instruction (manikin towards horizontal picture vs. manikin away from horizontal picture), the order of the CPT (CS+ first vs. CS- first), and the positioning of the two WWT (orange colour left vs. orange colour right)

were counterbalanced. After signing the first informed consent document, several questionnaires (PCS, FPQ, IUS, IRI, and PANAS) were completed.

The experiment consisted of three phases: (1) baseline, (2) observation, and (3) exposure (see *Figure 11* for an overview). During the baseline phase, participants performed the SRC task, preceded by a practice phase, and completed a numerical rating scale regarding their fear of each coloured Plexiglas box. At this point, participants were unaware of possible immersions of the hand into the coloured liquids, which was particularly important for the closed cover condition. Therefore, we did not explicitly ask for pain-related fear, pain unpleasantness or intensity in order to avoid priming effects. During the observation phase, eight different video clips, showing models' facial expressions and the coloured water tanks, were displayed on the computer screen. Each fragment was preceded by a US-expectancy rating: Participants were asked to report to which degree they expected a painful facial expression to appear in the next video clip. After watching the observation videos, participants performed the SRC task, and answered questions about possible mediators responsible for the painful facial expressions of the models. Next, several questions related to the properties of the coloured water were presented, but this time they explicitly mentioned the words pain-related fear, pain unpleasantness, pain intensity, and perceived harmfulness. Then, a second informed consent was signed, stating that participants would perform both WWT themselves. Subsequently, numerical rating scales were presented concerning behavioural avoidance tendencies, state catastrophizing, and preference for one of the two WWT. During the exposure phase, participants were requested to consecutively immerse one hand into the first WWT, and the second hand in the other WWT for as long as possible, without being aware of the maximum duration of the tasks, which was 4 minutes. Each WWT was preceded by a water immersion at room temperature, presentation of anticipatory numerical rating scales regarding properties of being in contact with the coloured water, and ratings of participants' state catastrophizing. One minute after each immersion, retrospective questions about the properties of the WWT were asked. At the end of the experiment, contingency awareness was investigated by means of a categorisation task, and participants were debriefed about the objectives and broader context of the study.

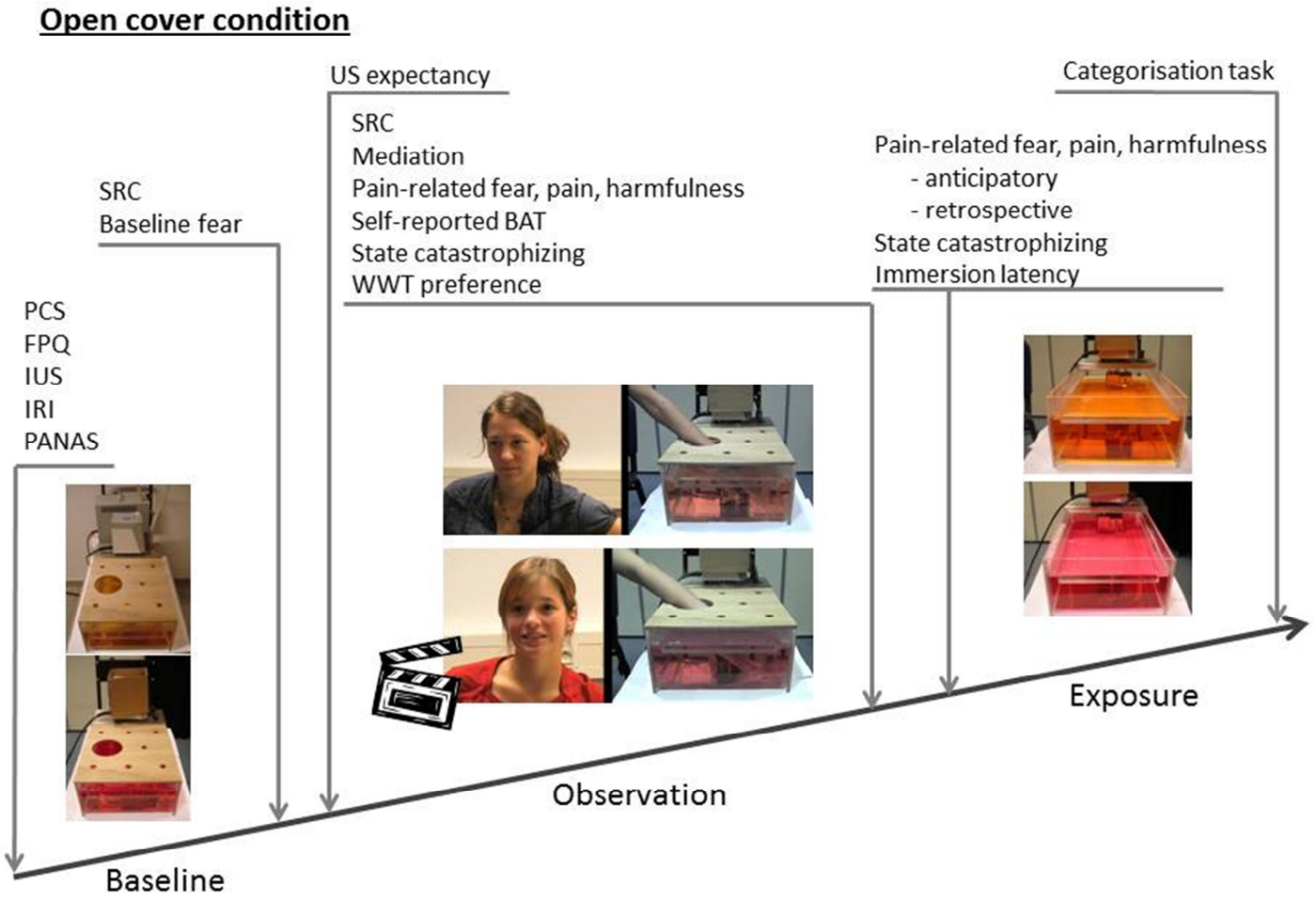
2.5 Statistical analyses

Regarding the *SRC* data, full trial median RT per stimulus type (CS+ vs. CS-), per response direction (approach vs. avoidance) was determined for each participant, excluding RT of incorrect responses. Subsequently, median scores in the approach condition were subtracted from medians in the avoidance condition for each stimulus type separately to compute compatibility scores. As a result, the relative strength of approach and avoidance regarding both stimulus types was measured, with positive scores representing stronger approach tendency, and negative scores representing stronger avoidance.

Mixed model statistical analyses were conducted with stimulus type (CS+ versus CS-) and time (baseline, observation, and exposure) as within-subject factors. For each dependent variable, two models were compared: (1) stimulus type, time and stimulus type x time as fixed effects, and intercept as a random effect, (2) stimulus type, time and stimulus type x time as fixed effects, and intercept and time as random effects. The model with the significantly lowest (full) maximum likelihood produces the best fit. For most dependent variables, the first model (with the random intercept and fixed slope) yielded the best fit. Hence, in order to preserve consistency, all analyses were conducted using this model. The same model was also used in moderation analyses, entering centred PCS, FPQ, IUS, IRI or PANAS-NA scores as covariates. Significant statistical interactions between stimulus type and questionnaire scores represented moderation effects (Baron & Kenny, 1986). Differential effects (CS+ vs. CS-) for individuals scoring higher or lower on the moderator variable were investigated by centring the covariates around the -1 *SD* (lower moderator scores) or +1 *SD* value (higher moderator scores).

Bootstrapping is the recommended technique to examine possible mediating variables in a multiple mediator model (Preacher & Hayes, 2008). It was used to construct bias-corrected and accelerated 95% confidence intervals around a point estimate of the indirect effects. In the current study, 5000 samples with replacement were executed from the original sample. Differential fear (Fear CS+ minus Fear CS-) was used as the dependent variable in the model. If the confidence interval of the indirect effect does not include zero, the mediator is significant.

All analyses were conducted with an alpha ≤ 0.05, using SPSS 19.0. Bonferroni corrections were implemented in all pairwise comparisons. The use of mixed model analyses can result in the report of fractionated denominator degrees of freedom, which are obtained by a Satterthwaite approximation (Satterthwaite, 1946).


Open cover condition
US expectancy
SRC
Mediation
Pain-related fear, pain, harmfulness
Self-reported BAT
State catastrophizing
WWT preference
Categorisation task
Pain-related fear, pain, harmfulness
- anticipatory
- retrospective
State catastrophizing
Immersion latency
SRC
Baseline fear
PCS
FPQ
IUS
IRI
PANAS
Exposure
Observation
Baseline

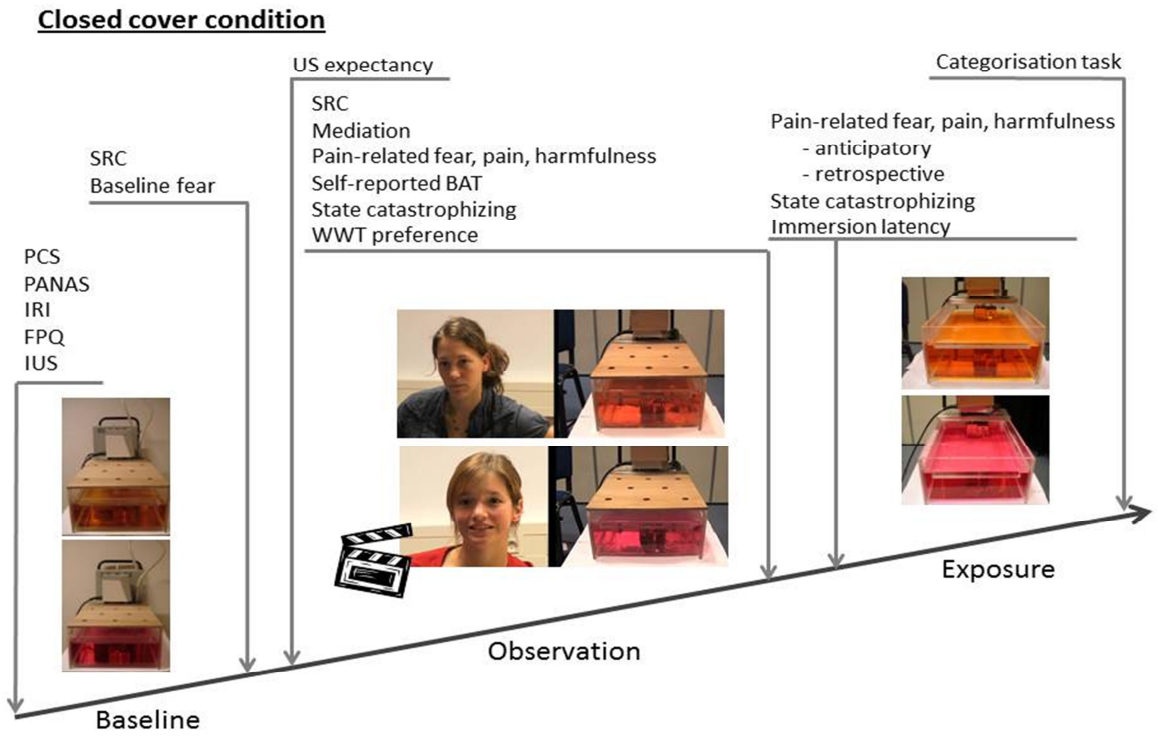


Figure 11. Graphical overview of the experimental procedure for the open and closed cover condition, with the measurements during baseline, observation, and exposure phase. During the observation phase, one colour was associated with painful facial expressions of the video models (bottom), while the other colour was paired with neutral expressions (top).

PCS = Pain Catastrophizing Scale; IUS = Intolerance of Uncertainty Scale; FPQ = Fear of Pain Questionnaire; IRI = Interpersonal Reactivity Index; PANAS = Positive And Negative Affect Schedule; US = Unconditioned Stimulus; SRC = Stimulus response compatibility task; BAT = Behavioural avoidance tendency; WWT = Warm water task.

Table 6. Means (*M*), Standard Deviations (*SD*), Cronbach's Alpha, and Pearson Intercorrelations of the Questionnaires and subscales.

	M	*SD*	Cronbach's alpha	2	3	4	5	6	7	8
1 PCS	17.48	6.74	.82	.16	.29*	-.17	-.02	.02	.35**	.33*
2 IUS	67.53	10.71	.80		.44**	.001	.12	.25	.28*	.36**
3 FPQ	78.33	15.84	.88			.15	.25	.22	.37**	.15
4 IRI PT	17.40	5.30	.80				.24	.32*	-.02	.02
5 IRI FS	19.58	5.42	.81					.46**	.20	.28*
6 IRI EC	19.17	3.85	.61						.03	.14
7 IRI PD	14.65	3.96	.64							.23
8 PANAS_NA	20.38	5.50	.78							

Note. PCS = Pain Catastrophizing Scale; IUS = Intolerance of Uncertainty Scale; FPQ = Fear of Pain Questionnaire; IRI = Interpersonal Reactivity Index, PT = Perspective Taking, FS = Fantasy, EC = Empathic Concern, PD = Personal distress; and PANAS_NA = Positive And Negative Affect Schedule - Negative Affectivity subscale.

* $p < .05$, ** $p < .01$.

Table 7. Means (*M*), standard errors (*SE*), and confidence intervals (95% CI) for the different dependent variables throughout the experiment.

		Baseline			Observation			Exposure					
								Anticipatory			Retrospective		
	Type	*M*	*SE*	95%CI	*M*	*SE*	95%CI	*M*	*SE*	95%BI	*M*	*SE*	95%CI
Fear	CS+	2.47	2.09	1.91 – 3.02	4.58	0.30	4.00 – 5.17	4.58	0.30	4.00 – 5.17	2.77	0.30	2.18 – 3.36
	CS-	2.27	2.26	1.71 – 2.82	3.53	0.30	2.94 – 4.12	3.45	0.30	2.86 – 4.04	2.17	0.30	1.58 – 2.76
Unpl	CS+	-	-	-	6.20	0.24	5.72 – 6.68	6.35	0.24	5.87 – 6.83	5.08	0.24	4.60 – 5.56
	CS-	-	-	-	5.43	0.24	4.95 – 5.91	5.48	0.24	5.00 – 5.96	4.90	0.24	4.42 – 5.38
Pain	CS+	-	-	-	4.80	0.30	4.21 – 5.39	4.78	0.30	4.19 – 5.38	2.92	0.30	2.32 – 3.51
	CS-	-	-	-	3.12	0.30	2.52 – 3.71	3.58	0.30	2.99 – 4.18	2.52	0.30	1.92 – 3.11
Harm	CS+	-	-	-	3.08	0.26	2.57 – 3.60	2.58	0.26	2.07 – 3.10	1.45	0.26	0.94 – 1.96
	CS-	-	-	-	2.18	0.26	1.67 – 2.70	2.05	0.26	1.54 – 2.56	1.35	0.26	0.84 – 1.86
BAT	CS+	-	-	-	5.33	0.27	4.80 – 5.87	-	-	-	-	-	-
	CS-	-	-	-	6.50	0.27	5.96 – 7.04	-	-	-	-	-	-
Cata1	CS+	-	-	-	4.70	0.35	4.01 – 5.39	4.63	0.35	3.94 – 5.32	-	-	-
	CS-	-	-	-	3.38	0.35	2.69 – 4.07	4.05	0.35	3.36 – 4.74	-	-	-
Cata2	CS+	-	-	-	2.55	0.27	2.02 – 3.08	2.15	0.27	1.62 – 2.68	-	-	-
	CS-	-	-	-	2.05	0.27	1.52 – 2.58	2.00	0.27	1.47 – 2.53	-	-	-
Cata3	CS+	-	-	-	4.08	0.32	3.46 – 4.71	3.70	0.32	3.07 – 4.33	-	-	-
	CS-	-	-	-	2.92	0.32	2.29 – 3.54	2.98	0.32	2.36 – 3.61	-	-	-
SCR (ms)	CS+	-42.51	28.64	-98.93;-13.92	47.02	28.40	-8.93;102.98	-	-	-	-	-	-
	CS-	83.80	28.64	27.37;140.22	82.45	28.40	26.50;138.40	-	-	-	-	-	-
Immersion	CS+	-	-	-	-	-	-	9939	425	9078-10769	-	-	-
latency (ms)	CS-	-	-	-	-	-	-	10295	429	9443-11148	-	-	-

Note. Investigated dependent variables were pain-related fear, pain unpleasantness, pain intensity, perceived harmfulness, self-reported behavioural avoidance tendencies (BAT), state catastrophizing (1 Rumination about the pain, 2 The possibility of something bad happening, and 3 The feeling that one could not endure the pain), stimulus response compatibility (SRC), and immersion latency time, respectively. During the baseline, the observation phase, and the anticipatory part of the exposure phase, expectations were measured, while during the retrospective part of the exposure phase, measures were related to real experiences. CS+ = aversive conditioned stimulus, CS- = neutral conditioned stimulus.

3 Results

3.1 Sample characteristics

Descriptive statistics, reliability, and Pearson inter-correlations regarding the questionnaire total scores and subscales are summarized in Table 6. Mean scores were comparable to what has been reported in previous research (de Bruin, et al., 2006; De Corte, et al., 2007; Peeters, et al., 1996; Roelofs, et al., 2005; Van Damme, et al., 2002). In addition, an overview was provided with descriptive information concerning the most important outcome variables of the study (Table 7).

3.2 Contingency awareness

US expectancy. An interaction was found between stimulus type and time, $F(3;420) = 12.67$, $p < .001$, providing support for CS-US contingency learning. CS+/CS- differentiation enlarged throughout the observation phase. Differential US expectancy was even more pronounced in the condition with the closed WWT covers, $F(1;420) = 14.31$, $p < .001$ (CS+ open: $\beta = .19$, $p = .04$; CS- open: $\beta = -.13$, ns; CS+ closed: $\beta = .38$, $p < .001$; CS- closed: $\beta = -.22$, $p = .02$).

Categorisation task. Forty-five participants correctly categorised all four painful facial expressions as CS+ pictures (75.0%). Twelve persons made one error (20.0%), and 3 individuals associated two painful facial expressions with the CS- WWT (5.0%). When asked about the categorisation criterion, 73.3% of the participants in the open cover condition and 76.7% of the participants in the closed cover condition referred to the contingency between the colour of the water and the facial expressions of the video models (CS – primary US), while 60.0% in the open versus 76.7% in the closed cover condition mentioned the contingency between the colour of the water and the properties of the water (e.g., warm, painful) (CS – secondary US).

3.3 Self-reports

3.3.1 Baseline fear

At the start of the experiment, no difference in fear between the two coloured Plexiglas boxes was found, $F(1;60) = 0.79$, ns. Results were the same for both conditions (closed vs. open cover), $F(1;60) = 0.07$, ns.

3.3.2 Self-reported pain-related fear, pain, and harmfulness

Pain-related fear, pain, and harmfulness before the immersions. After watching the video clips as well as immediately before each immersion, participants reported more pain-related fear with respect to the CS+ WWT relative to the CS- WWT, $F(1;180) = 22.93$, $p < .001$. They also expected the CS+ task to be more unpleasant, painful, and harmful compared to the CS- task, $F(1;180) = 19.80$, $p < .001$; $F(1;180) = 35.26$, $p < .001$; $F(1;180) = 15.20$, $p < .001$, respectively. No effects of time or interactions between stimulus type and time were found for these dependent variables, and results did not differ depending on the condition (open vs. closed cover) (all $p > .05$).

Pain catastrophizing moderated the relationship between stimulus type and fear, $F(1;180) = 6.11$, $p = .01$, stimulus type and pain unpleasantness, $F(1;180) = 4.86$, $p = .03$, and stimulus type and pain intensity, $F(1;180) = 4.60$, $p = .03$. High pain catastrophizers reported more pain-related fear concerning the CS+ compared to the CS-, $F(1;58) = 19.30$, $p < .001$, and expected the CS+ to be more unpleasant, and painful than the CS- task, $F(1;58) = 12.35$, $p < .001$; $F(1;58) = 19.99$, $p < .001$, respectively. For low pain catastrophizers, no differential effects were found on pain-related fear, $F(1;58) = 2.07$, ns, or pain unpleasantness, $F(1;58) = 1.45$, ns, although they expected more intense pain with regard to the CS+ compared to the CS-, $F(1;58) = 4.41$, $p = .04$. **Intolerance of uncertainty** (IUS), **trait fear of pain** (FPQ), and empathic **fantasy** (IRI FS) facilitated observational learning effects for pain-related fear, expected pain unpleasantness, pain intensity, and harmfulness, (IUS: $F(1;180) = 10.38$, $p = .002$; $F(1;180) = 4.59$, $p = .03$; $F(1;180) = 8.80$, $p = .003$; $F(1;180) = 11.42$, $p = .001$; FPQ: $F(1;180) = 4.99$, $p = .03$; $F(1;180) = 5.13$, $p = .02$; $F(1;180) = 4.19$, $p = .04$; $F(1;180) = 7.93$, $p = .005$; IRI FS: $F(1;180) = 6.22$, $p = .01$; $F(1;180) = 4.07$, $p = .04$; $F(1;180) = 7.27$, $p = .01$; $F(1;180) = 5.15$, $p = .02$, respectively). Participants with higher intolerance of uncertainty, trait fear of pain, or fantasy reported more pain-related fear, pain unpleasantness, pain intensity, and harmfulness regarding the CS+ compared to the CS- (IUS: $F(1;58) = 24.53$, $p < .001$; $F(1;58) = 12.10$, $p < .001$; $F(1;58) = 24.65$, $p < .001$; $F(1;58) = 22.55$, $p < .001$; FPQ: $F(1;58) = 18.02$, $p < .001$; $F(1;58) = 12.57$, $p < .001$; $F(1;58) = 19.31$, $p < .001$; $F(1;58) = 19.48$, $p < .001$; IRI FS: $F(1;58) = 19.08$, $p < .001$; $F(1;58) = 11.38$, $p < .001$; $F(1;58) = 23.12$, $p < .001$; $F(1;58) = 16.40$, $p < .001$), whereas for participants with lower intolerance of uncertainty or fantasy no differential effects were found (IUS: $F(1;58) = 1.06$, ns; $F(1;58) = 1.53$, ns; $F(1;58) = 3.01$, ns; $F(1;58) = 0.26$, ns; IRI FS: $F(1;58) = 2.13$, ns; $F(1;58) = 1.75$, ns; $F(1;58) = 3.41$, ns; $F(1;58) = 1.06$, ns, respectively). For participants with lower trait fear of pain no differential effects were found for pain-related fear, pain unpleasantness, and

harmfulness, $F(1;58) = 2.41$, ns; $F(1;58) = 1.39$, ns; $F(1;58) = 0.56$, ns, respectively, although they expected the CS+ task to be more painful than the CS- task, $F(1;58) = 4.67$, $p = .04$. **Empathic concern** (IRI EC) and **personal distress** (IRI PD) facilitated observational learning effects for pain-related fear, expected pain intensity, and harmfulness (IRI EC: $F(1;180) = 5.59$, $p = .02$; $F(1;180) = 7.52$, $p = .01$; $F(1;180) = 4.14$, $p = .04$; IRI PD: $F(1;180) = 3.92$, $p = .049$; $F(1;180) = 5.81$, $p = .02$; $F(1;180) = 14.52$, $p < .001$, respectively). Participants with higher empathic concern or higher personal distress showed more pain-related fear, and expected the CS+ task to be more painful and harmful relative to the CS- task (IRI EC: $F(1;58) = 18.80$, $p < .001$; $F(1;58) = 23.53$, $p < .001$; $F(1;58) = 14.58$, $p < .001$; IRI PD: $F(1;58) = 16.52$, $p < .001$; $F(1;58) = 21.40$, $p < .001$; $F(1;58) = 27.26$, $p < .001$, respectively), while for participants with lower empathic concern or personal distress no differential effects were found (IRI EC: $F(1;58) = 2.20$, ns; $F(1;58) = 3.30$, ns; $F(1;58) = 1.47$, ns; IRI PD: $F(1;58) = 2.88$, ns; $F(1;58) = 3.93$, ns; $F(1;58) = 0.03$, ns, respectively).

Pain-related fear, pain, and harmfulness after the immersions. Immediately after each immersion, no differences between the CS+ and CS- WWT were found for pain-related fear, pain unpleasantness, pain intensity, and harmfulness in either condition (all $p > .05$). None of the investigated characteristics of the observer had an influence on self-reported pain-related fear, pain or harmfulness after exposure to the WWT (all $p > .05$).

3.3.3 Self-reported Behavioural Avoidance Tendency

After observation of the video clips, participants were more willing to perform the WWT that was associated with the neutral facial expressions of the video models compared to the WWT associated with the painful facial expressions, $F(1;60) = 17.06$, $p < .001$. Results did not differ depending on the condition (open vs. closed cover), $F(1;60) = 1.05$, ns. No moderating influences were found for self-reported behavioural avoidance tendencies (all $p > .05$).

3.3.4 State catastrophizing about pain

Participants anticipated to ruminate more about the pain concerning the CS+ WWT compared to the CS- WWT, $F(1;180) = 16.88$, $p < .001$. They also expected to a higher extent that something bad could happen during the CS+ immersion, and that they would not be able to endure this immersion compared to the CS- immersion, $F(1;180) = 4.91$, $p = .03$; $F(1;180) = 18.24$, $p < .001$, respectively. No effects of time, or interactions between stimulus type and

time were found for the three dependent variables, and results were similar in both conditions (open vs. closed cover (all $p > .05$).

Pain catastrophizing facilitated expected pain of the immersion, and the feeling that one would not be able to endure the immersion, $F(1;180) = 4.97$, $p = .03$; $F(1;180) = 6.45$, $p = .01$, respectively. Higher pain catastrophizers expected more pain, and felt as if they would be less able to endure the CS+ immersion relative to the CS- immersion, $F(1;58) = 15.20$, $p < .001$; $F(1;58) = 16.48$, $p < .001$. For lower pain catastrophizers, no differential effects were found, $F(1;58) = 1.38$, ns; $F(1;58) = 1.05$, ns, respectively. **Intolerance of uncertainty** influenced the feeling that something bad could happen during the upcoming immersions, $F(1;180) = 7.04$, $p = .01$. Participants who were more intolerant of uncertainty expected to a greater extent that something bad would happen during the CS+ task compared to the CS- task, $F(1;58) = 6.02$, $p = .02$, whereas participants who were less intolerant of uncertainty showed no difference between the two tasks, $F(1;58) = 0.01$, ns. **Trait fear of pain** facilitated expected pain of the immersion, and the feeling something bad could happen, $F(1;180) = 3.93$, $p = .049$; $F(1;180) = 5.85$, $p = .02$, respectively. Participants with higher trait fear of pain scored higher with respect to the CS+ relative to the CS-, $F(1;58) = 13.79$, $p < .001$; $F(1;58) = 5.91$, $p = .02$, while for participants with lower trait fear of pain no differences were found, $F(1;58) = 1.75$, ns; $F(1;58) = 0.01$, ns, respectively. **Empathic concern** (EC) facilitated expected pain, $F(1;180) = 5.49$, $p = .02$. Participants with higher EC expected more pain with respect to the CS+ compared to the CS-, $F(1;58) = 15.76$, $p < .001$, whereas for participants with lower EC, no differences were found, $F(1;58) = 1.25$, ns. Finally, **personal distress** (PD) facilitated the feeling that something bad could happen and that one would not be able to endure the immersion, $F(1;180) = 9.81$, $p = .002$; $F(1;180) = 12.11$, $p = .001$, respectively. Participants with higher PD scored higher with regard to the CS+ than the CS- immersion, $F(1;58) = 7.89$, $p = .01$; $F(1;58) = 21.54$, $p < .001$, while for participants with lower PD no differential effects were found, $F(1;58) = 0.18$, ns; $F(1;58) = 0.34$, ns, respectively.

3.4 Avoidance behaviour

Stimulus Response Compatibility task. A main effect of stimulus type was found, $F(1;238) = 8.27$, p = .004, with participants showing stronger avoidance tendencies with regard to the CS+ compared to the CS-. No main effect of time, nor an interaction between stimulus type and time was found, $F(1;238) = 2.50$, ns; $F(1;238) = 2.63$, ns, respectively. Participants in the open cover condition did not differ from participants in the closed cover

condition, $F(1;238) = 1.42$, ns. None of the investigated observers' characteristics moderated stimulus response compatibility.

WWT preference. When asked in which WWT they would prefer to immerse their hand, 65.0% of the participants preferred to repeat the CS- task, whereas 26.7% reported a preference for the CS+ task. 8.3% of the participants showed no preference for either task. Results were similar for the open and closed cover condition.

Immersion latency. No difference in immersion latency time between the CS+ and CS- WWT was found, $F(1;46.73) = 0.46$, ns. None of the examined observers' characteristics moderated immersion latency (all $p > .05$), and results were similar in both conditions (open vs. closed cover), $F(1;49.55) = 2.27$, ns. No early withdrawals were registered.

3.5 Mediation

All of the bias-corrected and accelerated 95% confidence intervals (BCa 95% CI) of the indirect effect contained zero, meaning that none of the proposed causes mediated the effect between condition (open vs. closed cover) and differential pain-related fear.

4 Discussion

The current experimental study was aimed at investigating observational learning of pain-related fear, and subsequent extinction after first-hand exposure to the feared stimulus. Moreover, we were interested in the specific contingencies that are learned when observing others in pain. Finally, we explored whether observers' pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy facilitated the development of pain-related fear through observation. A differential fear conditioning paradigm was used, showing video models displaying either a painful (CS+ colour) or a neutral (CS- colour) facial expression in the presence of a coloured warm water task (WWT). In one condition (open cover), the models' hand immersed the coloured liquid, while in the other condition (closed cover), no contact was displayed between the model and the liquid. Afterwards, participants performed both WWT at the same temperature (45°C).

Results of the present study revealed successful acquisition of self-reported pain-related fear through observation. Participants also expected the WWT associated with the painful facial expressions of the video models to be more unpleasant, painful, and harmful relative to the WWT that was previously paired with the neutral facial expressions. These findings support previous research (Helsen, et al., 2011; Helsen, Vlaeyen, & Goubert, submitted). After watching the observation video, participants were less willing to perform

the CS+ WWT than the CS- WWT, and they catastrophized more in anticipation of the former compared to the latter. Pain catastrophizing, intolerance of uncertainty, trait fear of pain, and dispositional empathy facilitated these observational learning effects. After direct contact with both coloured WWT differential effects disappeared, providing evidence for the extinction of pain-related fear beliefs and cognitions. These findings are similar to those of a prior study using CPT (Helsen, et al., 2011), in which evidence was found for partial extinction of differential pain-related fear, and complete extinction of differences in pain unpleasantness and pain intensity.

Avoidance behaviour was operationalized in three different ways: An indirect reaction time task (SRC task), a forced choice task (WWT preference), and a direct reaction time measure (immersion latency). In line with our expectations, participants were more inclined to perform the CS- task compared to the CS+ task, and they showed stronger avoidance tendencies in the SRC task with respect to the CS+ relative to the CS- WWT, supporting earlier evidence (Gerull & Rapee, 2002). Regarding immersion latency time, no differential effects were observed, corroborating earlier findings (Helsen, et al., 2011). Hence, the acquisition of fear was associated with changes in some behavioural patterns, but not in others', and these were not facilitated by observers' characteristics.

Two different types of contingencies were explored in the current experiment. On the one hand, a directly experienced association could have been learned between the colour of the water (CS) and the painful facial expressions of the video models (primary US), rendering the colour of the water into a predictor for the facial expressions of the video models. On the other hand, an indirectly experienced contingency could have been acquired between the colour of the water (CS) and the assumed properties of (being in contact with) the water, namely being warm or painful (secondary US). By using an open versus closed cover condition, we intended to manipulate the contingencies that were learned while watching the observation video clips. We expected learning effects to be most pronounced in the condition with the open cover, as participants observed contact of the model with the coloured liquids, which would provoke learning of both the 'CS – primary US' and the 'CS – secondary US' contingency. In the closed cover condition, only the 'CS – primary US' contingency was hypothesized to be learned. As expected, the 'CS – primary US' contingency was learned in both conditions. Surprisingly, no differences were found between both conditions concerning the 'CS – secondary US' contingency. When asked about the sorting criterion in the categorisation task, the number of participants mentioning the indirect relationship was even bigger in the closed cover condition, suggesting that observational learning occurred in both

conditions. This rather unexpected result may be explained by the fact that the categorisation task was performed at the end of the experiment, so after participants' own immersions. We do not know whether the 'CS – secondary US' contingency has been learned during observation or during direct exposure to the WWT. Another possible explanation for this is that in both conditions steam was rising from the coloured CS+ WWT, which we did in order to keep both videos as much similar as possible. Consequently, participants might still have attributed the steam in the video in the CS+ closed condition to certain properties of the coloured liquid. This might also explain the absence of mediator effects on differential fear after observation of the video clips.

These findings may have implications for clinical practice. Many pain patients suffer from pain-related fear, which can be more disabling than the pain condition itself (Crombez, et al., 1999; Grotle, Vøllestad, Veierød, & Brox, 2004). De Peuter and colleagues (De Peuter, et al., 2009) suggested that tailoring pain treatment to individual patient characteristics might be a useful strategy in future pain management. Some individuals benefit more from treatment targeting pain-related fear than others. Early screening may help identifying individuals who are most prone to develop pain-related fear, for instance by observing pain in other patients. Such a triage might be a useful, cost-effective, non-time consuming method to optimize individual treatment outcome. Previous research has indicated that pain-related fear reduction in an early stage of low back pain increases participation in physical activity despite the pain (Swinkels-Meewisse, et al., 2006). Such early interventions might preserve part of them from the transition from acute to chronic pain. As pain-related fear can be extinguished after direct contact to the feared stimulus, exposure therapy, during which pain patients perform feared movements despite pain, is a promising behavioural treatment reducing excessive fears and avoidance behaviours and increasing quality of life (Bailey, et al., 2010; de Jong, Vlaeyen, Van Eijsden, Loo, & Onghena, 2012; Vlaeyen, et al., 2001; Vlaeyen, et al., 2012).

There are a number of limitations to the current study, which yield implications for future studies. The most important limitation lies in the sample used in this experiment. Only healthy, young females participated in the study, which makes generalisation to male and patient populations difficult. Second, due to technical difficulties we do not have any psychophysiological data at our disposal. Future studies could measure EMG startle responses, which are known to be a reliable pain fear-related measure (Meulders, et al., 2011). Finally, in the current study, extinction of pain-related fear was examined by means of direct exposure to the feared stimulus. It might be interesting to investigate whether pain-related fear also extinguishes after an observational exposure procedure showing the models performing

both WWT while displaying neutral facial expressions. Such a paradigm would enable us to examine whether information obtained through observation results in similar effects compared to a direct exposure procedure. In order to increase external validity, one could investigate interactions between different pathways during acquisition as well as during extinction, since in real life, fear pathways do not operate in isolation, and are likely to facilitate each other. Until today, research on the interactions between fear routes is very scarce. Field and Storkson-Coulson (2007) showed that threat information prior to direct negative experience with an unknown animal facilitates fear learning in children. In another study (Askew, Kessock-Philip, & Field, 2008), evidence was found for the facilitation of observational fear learning after receiving threatening information. However, when the information was provided during or after observational conditioning, effects were not larger compared to an observation alone condition. Further research could investigate whether these findings generalize to adults and also apply to pain-related fear.

In general, this study provided evidence for observational learning of pain-related fear, which can be extinguished after direct exposure to the feared stimulus. Hence, the current findings add to our understanding of psychological factors contributing to the development and continuation of pain problems.

CHAPTER V:

Confirmatory factor analysis of the Dutch Intolerance of Uncertainty Scale: Comparison of the full and short version

Abstract

The Intolerance of Uncertainty Scale (IUS) was developed for assessing reactions to ambiguous situations, uncertainty, and future events. The IUS has been validated in different languages, but equivocal factor structures, in combination with highly interrelated items and factors, resulted in a redundancy of the items of the English version. In the current study, the psychometric properties of the Dutch version of the IUS were examined, and compared with the shortened 12-item version (IUS-12). Confirmatory factor analyses were used to investigate different factor structures of both the full and short version of the IUS. Results indicated that the IUS-12 model with two factors (Prospective Anxiety and Inhibitory Anxiety) provides the best fit. The reduced measure has equally good internal consistency, and is highly correlated with the full version. Future research could investigate whether the current findings generalize to clinical populations. To summarize, the usage of the short 12-item version of the IUS should be encouraged in future research concerning intolerance of uncertainty.

Key words: Intolerance of Uncertainty, Confirmatory Factor Analysis, Worry

Helsen, K., Van den Bussche, E., Vlaeyen, J. W. S., & Goubert, L. (2013). Confirmatory factor analysis of the Dutch Intolerance of Uncertainty Scale: Comparison of the full and short version. Journal of Behavior Therapy and Experimental Psychiatry, 44, 21-29.

1 Introduction

Worry is a central characteristic of Generalized Anxiety Disorder (GAD), but also occurs frequently in other mental disorders such as obsessive compulsive disorder (Sica, Coradeschi, Sanavio, & Novara, 2004), social anxiety (Boelen & Reijntjes, 2009), depression (Yook, Kim, Suh, & Lee, 2010), panic disorder with agoraphobia (Dugas, Marchand, & Ladouceur, 2005), post-traumatic stress disorder (Boelen, 2010), eating disorders (Konstantellou, Campbell, Eisler, Simic, & Treasure, 2011; Sternheim, Startup, & Schmidt, 2011), and somatoform disorders (Boelen & Carleton, 2012; Deacon & Abramowitz, 2008). In addition, as much as 38% of the general population report to worry at least once a day (Tallis, Davey, & Capuzzo, 1994). Therefore, it is important to identify the key factors responsible for the development and maintenance of worry (Buhr & Dugas, 2002). One dispositional characteristic that is often associated to both the origin and the continuation of worry, is intolerance of uncertainty (IU) (de Bruin, et al., 2006; Dugas, Gagnon, Ladouceur, & Freeston, 1998; Freeston, et al., 1994), defined by Ladouceur, Gosselin, and Dugas (2000) as "the predisposition to react negatively to an uncertain event or situation, independent of its probability of occurrence and of its associated consequences" (p. 934). Worriers have difficulty enduring uncertainty (Buhr & Dugas, 2002). For instance, worriers have been shown to display more difficulties completing ambiguous tasks compared to non-worriers, operationalized by longer decision times in a categorisation task, caused by an increase in disrupting negative thoughts (Metzger, Miller, Cohen, Sofka, & Borkovec, 1990). They also tend to interpret uncertain or ambiguous situations in a more threatening way (Butler & Matthews, 1983; Hedayati, Dugas, Buhr, & Francis, 2003; Russell & Davey, 1993), needing more information before making a decision (Tallis, Eysenck, & Mathews, 1991). Given that ambiguous situations provoke uncertainty, and increase the desire for predictability, which is a typical aspect of intolerance of uncertainty specific to worry, these findings suggest that worriers have a lower threshold for uncertainty compared to non-worriers (Buhr & Dugas, 2002). In addition, high intolerance of uncertainty may lead to impaired problem solving, resulting in inaction or even avoidance of ambiguous situations (Dugas, Freeston, & Ladouceur, 1997). Furthermore, cognitive-behavioural treatment targeting excessive worry in GAD was related to a significant decrease in IU over treatment (Ladouceur, Dugas, et al., 2000). Beneficial effects regarding both GAD symptoms and IU were still present after a 12-month follow-up period. Results of another longitudinal study by Dugas and Ladouceur (2000) showed that changes in IU preceded changes in time spent worrying, suggesting that IU might mediate changes in worry during GAD treatment. IU was also found to be a better

predictor of worry than beliefs about worry, negative problem orientation, and cognitive avoidance (Laugesen, Dugas, & Bukowski, 2003). Moreover, experimental manipulation of IUS was shown to influence the number of worrying thoughts (Ladouceur, Gosselin, et al., 2000; Rosen & Knäuper, 2009). These findings seem to suggest that IU is a causal risk factor for pathological worry (Dugas, et al., 2005).

One measure that has often been used to asses IU is the Intolerance of Uncertainty Scale (IUS). The original French version of the IUS was developed to assess "emotional, cognitive, and behavioural reactions to ambiguous situations, implications of being uncertain, and attempts to control the future" (Freeston, et al., 1994, p. 791). Factor analysis yielded a five-factor solution that comprised the following factors: (1) Uncertainty is unacceptable and should be avoided, (2) Being uncertain reflects badly on a person, (3) Frustration is related to uncertainty, (4) Uncertainty causes stress, and (5) Uncertainty prevents action. IUS scores allowed to differentiate between groups of non-clinical subjects, who reported either no GAD symptoms, only somatic symptoms, or both somatic and cognitive symptoms. Additionally, partial correlation analyses showed that IU accounts for significant variance in worry scores, above and beyond the influence of anxiety and depression. Although a 5-factorstructure emerged from psychometric analysis, high internal consistency justified the use of a single summary score of the questionnaire. With regard to the factor analysis of the English version, a four-factor structure turned out to be more suitable. These factors were (1) Uncertainty leads to the inability to act, (2) Uncertainty is stressful and upsetting, (3) Unexpected events are negative and should be avoided, and (4) Being uncertain about the future is unfair (Buhr & Dugas, 2002). Validity and reliability measures were comparable to the ones of the French version, and consistent among four racial groups (Norton, 2005). However, the factor structures in the cross-cultural study were not consistent among groups, with the considerably correlated factors suggesting that IU should best be interpreted as a unidimensional construct (Norton, 2005). Subsequently, Sexton and Dugas (2009) reinvestigated the factor structure of the English IUS, using larger samples. Exploratory factor analysis (EFA) identified two factors: (1) Uncertainty has negative behavioural and self-referent implications, and (2) Uncertainty is unfair and spoils everything, which were substantiated by confirmatory factor analysis (CFA). Finally, investigation of the Dutch translation of the 27-item IUS favoured the use of a one-factor solution, measuring overall intolerance of uncertainty (de Bruin, et al., 2006). The instability of the IUS factor structure, despite large sample sizes, in combination with high inter-factor correlations, supported redundancy of the items (Norton, 2005). Carleton, Norton, and Asmundson (2007) developed an English 12-item version of the IUS.

This abridged version showed a stable two-factor structure, representing prospective as well as inhibitory components of IU. While the former component covers future-related uncertainty, the latter involves uncertainty inhibiting action or experience. Psychometric properties were similar to the full version's properties, resulting in a preference of the use of the IUS-12 to the full version.

The aim of the current study was to further examine the utility of the abbreviated version of the IUS in a sample of healthy undergraduate students and adults, using the Dutch version of the questionnaire. Confirmatory factor analyses were conducted for the unitary, two-, four-, and five-factor structure of the full 27-item version, and compared to the fit of the one- and two-factor solutions of the abridged 12-item version. After selection and validation of the optimal model, invariance across gender was examined, and psychometric properties of this model were investigated. We hypothesized that IU was uniquely related to worry, over and above levels of anxiety and depression.

2 Method

2.1 Participants

Participants were 967 healthy undergraduate students and adults with a mean age of 19.55 (*SD* = 3.65, median = 18, range 14-65). In this sample, 176 were male (18.2%), 784 were female (81.1%), and seven participants chose not to specify their gender or age (0.7%). In the current study, participants only completed the full version of the IUS. Relevant IUS-12 items were derived afterwards to include in the analyses. In order to investigate validation of the IUS, a subsample completed the Beck Depression Inventory (BDI-II, *N* = 470), the Penn State Worry Questionnaire (PSWQ, *N* = 521), and the trait version of the State Trait Anxiety Inventory (STAI-T, *N* = 626). Participants signed the informed consent form after being informed about the procedure of the study. Ethical approval was obtained from the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium).

2.2 Measures

2.2.1 Intolerance of uncertainty

IUS-27. The full version of the Intolerance of Uncertainty Scale (IUS) (Buhr & Dugas, 2002; de Bruin, et al., 2006; Freeston, et al., 1994) consists of 27 items considering different propositions regarding uncertain or ambiguous situations (e.g., 'I always want to know what

the future has in store for me', 'When it's time to act, uncertainty paralyses me'). Participants were requested to indicate to what extent they agreed with these propositions (1 = *Not at all representative*; 5 = *Completely representative*) (see Appendix A). The original French version, as well as the translated English and Dutch variations on the IUS, have shown satisfactory psychometric properties, with internal consistency ranging from .88 to .94, and test-retest reliability scores varying from $r = .74$ to $r = .79$ over a four (de Bruin, et al., 2006) or five week period (Buhr & Dugas, 2002; Dugas, et al., 1997; Freeston, et al., 1994). The IUS has been used in clinical as well as non-clinical populations (Boelen & Reijntjes, 2009; de Bruin, et al., 2006), most commonly summed as a total scale score (Roemer, 2001), with higher scores representing greater intolerance of uncertainty.

IUS-12. The abbreviated version of the IUS was developed by Carleton et al. (2007) (see Appendix B), as a response to the inconsistent findings of several factor analyses using different languages (Buhr & Dugas, 2002; de Bruin, et al., 2006; Freeston, et al., 1994) and cross-cultural comparisons (Norton, 2005). The abbreviation of the IUS occurred as follows: CFA of the different factor structures of the IUS-27 did not provide an adequate fit. Consequently, Carleton et al. (2007) selected two factors, one factor of the four-factor model (i.e. Uncertainty leading to inability to act) and one of the five-factor structure (i.e. Unacceptability and avoidance of uncertainty) based on the principle of item-independence (each model had one factor for which the items where shared between all but one of the factors in the other model (Carleton, Norton, et al., 2007, p. 110)). This resulted in a 17-item questionnaire. Subsequently, two items were dropped because of strong correlations with another item. The item with the highest factor loading and superior face validity was preserved. Finally, three more items were deleted by the authors because they were considered to be more strongly related to self-esteem and indecision than to their parent factors, yielding a 12-item questionnaire.

The IUS-12 is highly correlated with the full version ($r = .96$), and has high internal consistency ($\alpha = .85$) (Carleton, Norton, et al., 2007). Two factors can be distinguished: Prospective Anxiety (PA: Future-related fear and anxiety; item 1-7; $\alpha = .87$), and Inhibitory Anxiety (IA: Uncertainty inhibiting action or experience; item 8-12; $\alpha = .90$) (Carleton, Collimore, & Asmundson, 2010).

2.2.2 Worry

The Penn State Worry Questionnaire (PSWQ) (Meyer, Miller, Metzger, & Borkovec, 1990; van Rijsoort, Emmelkamp, & Vervaeke, 1999) is a 16-item questionnaire, developed to measure trait worry. The items deal with the inclination, intensity and uncontrollability of

worrying (e.g., 'Many situations make me worry', 'My worries overwhelm me', 'Once I start worrying, I can't stop'). Participants are requested to indicate how well the 16 statements describe themselves on a 5-point Likert scale, ranging from 1 (not typical at all) to 5 (very typical). Items 1, 3, 8, 10, and 11 need to be reverse-scored before computing the total score. In most studies worry is considered a unidimensional construct (Brown, Antony, & Barlow, 1992; Meyer, et al., 1990; van Rijsoort, et al., 1999), although confirmatory factor analysis in a student population (Fresco, Heimberg, Mennin, & Turk, 2002) indicated that a two factor structure, with Worry engagement and Absence of worry as factors, provides a better fit. The PSWQ has proven to have good test-retest reliability over an 8-10 week period (Meyer, et al., 1990). Moreover, high internal consistency of the PSWQ was found for both clinical (α = .86 - .93) (Brown, et al., 1992) and non-clinical samples (α = .90 - .95) (Davey, 1993; Meyer, et al., 1990; Molina & Borkovec, 1994). Cronbach's alpha in the current study was excellent (α = .92). The PSWQ significantly correlates with depression (Beck Depression Inventory: r = .36 - .62) (Meyer, et al., 1990; van Rijsoort, et al., 1999) and anxiety (Trait version of the State Trait Anxiety Inventory: r = .64 - .75) (Davey, 1993; Meyer, et al., 1990; van Rijsoort, et al., 1999).

2.2.3 Depression

The Beck Depression Inventory (BDI-II) (Beck, Steer, & Brown, 1996; Van der Does, 2002) comprises 21 four-choice statements assessing the severity of depressive symptoms such as anhedonia, indecisiveness, and feelings of guilt. Participants indicate which of the four sentences describes them the best, considering the previous two week period, including the day of testing. The total score of the 21 items ranges from 0 to 63, with higher scores indicating higher levels of depression. Internal consistency of the Dutch version has been shown to be excellent in both clinical (α = .92) and student samples (α = .93). In the current study, Cronbach's alpha was .85.

2.2.4 Anxiety

Dispositional anxiety was measured by the trait version of the State-Trait Anxiety Inventory (STAI-T) (Spielberger, Gorsuch, & Luschene, 1970; Van der Ploeg, 1980, 1999). Participants are required to specify to what extent they generally experience the 20 emotions presented (e.g., 'I feel calm', 'I am worried'). Items are scored on a 4-point Likert scale, ranging from A *(hardly ever)* to D *(almost always)*, yielding a total score between 20 and 80. Higher scores on the STAI-T represent higher anxiety levels. Test-retest reliability ranges from .73 to .86, and the STAI-T has good internal consistency in both students (α = .81)

(Belzer, D'Zurilla, & Maydeu-Olivares, 2002), and anxiety disorder patients (α = .89) (Bieling, Antony, & Swinson, 1998). However, internal consistency in the current study was limited (α = .40).

2.3 Statistical strategy

The statistical analyses were performed using Amos version 19.0 (Arbuckle, 2010) and SPSS 17.0 (SPSS Inc.). We randomly split the full sample of cases into two subsamples, a calibration sample (N = 483) and a validation sample (N = 484). The split-sample strategy (Browne & Cudeck, 1993; Cudeck & Browne, 1983) was used for cross-validation. The calibration sample was used to assess the different IUS models. The validation sample was used to validate the final best fitting model. First, confirmatory factor analyses were used to select the optimal model of the IUS based on the factor structures. Six alternative models, which have been previously proposed in the literature (Buhr & Dugas, 2002; Carleton, Norton, et al., 2007; de Bruin, et al., 2006; Freeston, et al., 1994; Sexton & Dugas, 2009), were tested using the calibration sample. Standardized scores on the constructs were estimated. The Maximum Likelihood algorithm was used to assess the fit of the model. In line with theoretical recommendations (Bollen & Long, 1993; Byrne, 2001), several fit indices were used to assess the model fit: χ^2, root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI) and the Consistent Akaike Information Criterion (CAIC). A non-significant χ^2 value indicates an acceptable model (Marsch, Balla, & McDonalds, 1988). Values of RMSEA up to .08 (Browne & Cudeck, 1993), GFI > .90 and AGFI >.85 (Jöreskog & Sörbom, 1984) and CFI >.90 (Bentler, 1990) indicate proper fit. The CAIC can be used to compare non-hierarchical as well as hierarchical (nested) models, with lower values on the CAIC measure indicating better fit (Burnham & Anderson, 1998).

After selecting the optimal model and validating it using the validation sample, we examined whether it was invariant across gender by conducting a multi-sample analysis across the full sample (calibration and validation sample). A very restrictive model was tested by equating the number of factors, the factor loadings, and the correlations between the factors. Internal consistency of the derived optimal model was examined using Cronbach's alpha in the full sample. The construct validity of the derived optimal model was confirmed by examining the association with worry (PSWQ), trait anxiety (STAI-T), and depression (BDI-II) in the full sample using Pearson correlations and hierarchical multiple regression analysis.

3 Results

3.1 Confirmatory factor analysis

Using the calibration sample, the model fit of the six IUS models was assessed. Table 8 summarizes the goodness-of-fit indices of all six models of the IUS. The indices suggest that the optimal fit is obtained for a two-factor model of the 12-item version of the IUS (Carleton, et al., 2007). This model shows an acceptable fit ($\chi^2(53)=155.89$, $p<.001$; GFI= .95; AGFI= .92; CFI= .92; RMSEA= 0.064 (90% CI: 0.053–0.076)). All other models have a poorer fit to the data (Table 8), which is also indicated by the CAIC values. Using the validation sample, the model of Carleton et al. (2007) was cross-validated. Goodness-of-fit indices again indicate a reasonable fit ($\chi^2(53)=127.78$, $p<.001$; GFI= .96; AGFI= .94; CFI= .94; RMSEA= 0.055 (90% CI: 0.042–0.067). This indicates that the model was robust across two similar samples of healthy undergraduate students and adults.

Table 9 shows the standardized factor loadings for the validation and the calibration sample. The correlation between the two factors was .74 in the calibration sample and .75 in the validation sample.

Table 8. Confirmatory factor analyses fit indices for the different IUS versions

	χ^2(df), *p*	GFI	AGFI	CFI	RMSEA (90% CI)	CAIC
IUS-27[a], 1 factor	χ^2(324)=1262,94, *p*<.001	.80	.76	.75	.079 (.074-.084)	1648.61
IUS-27[a], 2 factors	χ^2(323)=1023.37, *p*<.001	.85	.82	.81	.068 (.064-.073)	1416.18
IUS-27[a], 4 factors	χ^2(318)=1090.33, *p*<.001	.84	.80	.79	.072 (.068-.077)	1518.85
IUS-27[a], 5 factors	χ^2(286)=769.01, *p*<.001	.88	.85	.86	.060 (.055-.065)	1233.24
IUS-12[a], 1 factor	χ^2(54)=236.96, *p*<.001	.91	.87	.86	.085 (.074-.096)	408.93
IUS-12[a], 2 factors	χ^2(53)=155.89, *p*<.001	.95	.92	.92	.064 (.053-.076)	334.92
IUS-12[b], 2 factors	χ^2(53)=127.78, *p*<.001	.96	.94	.94	.055 (.042-.067)	306.92

Note. [a] = Calibration sample (*N*=483), [b] = Validation sample (*N*=484).

GFI = goodness-of-fit index, AGFI = adjusted goodness-of-fit index, CFI = comparative fit index, RMSEA = root mean square error of approximation, and CAIC = the Consistent Akaike Information Criterion.

Table 9. Standardized factor loadings of the two-factor model for the 12-item IUS (Carleton, Norton, and Asmundson, 2007) as obtained with confirmatory factor analysis shown for the validation sample and the calibration sample (between parentheses)

Item	Item content	prospective anxiety	inhibitory anxiety
1	Unforeseen events upset me greatly.	.62 (.63)	
2	It frustrates me not having all the information I need.	.50 (.60)	
3	One should always look ahead so as to avoid surprises.	.62 (.52)	
4	A small unforeseen event can spoil everything, even with the best planning.	.51 (.53)	
5	I always want to know what the future has in store for me.	.63 (.62)	
6	I can't stand being taken by surprise.	.60 (.54)	
7	I should be able to organize everything in advance.	.57 (.68)	
8	Uncertainty keeps me from living a full life.		.58 (.57)
9	When it's time to act, uncertainty paralyses me.		.68 (.59)
10	When I am uncertain, I can't function very well.		.49 (.44)
11	The smallest doubt can stop me from acting.		.66 (.67)
12	I must get away from all uncertain situations.		.57 (.56)

3.2 Test of stability of the two-factor model of Carleton et al. (2007) across gender

To examine whether the two-factor model of Carleton et al. (2007) was invariant across gender, a multi-sample analysis was conducted separately for men (N = 171) and women (N = 772). The results of the multi-sample analysis showed that the model adequately fitted the data: $\chi^2(119)=307.66$, $p<.001$; GFI= .95; AGFI= .93; CFI= .93; RMSEA= 0.041 (90% CI: 0.035–0.047. This indicates that the model is stable in both samples for the number of factors (invariant factor numbers), the intercorrelations between factors (invariant factor intercorrelations), and for the contribution of all items to their respective factors (invariant factor loadings).

3.3 Psychometric properties of the model with the best fit

3.3.1 Descriptive data

Descriptive statistics, the internal consistency, and Pearson inter-correlations for the different questionnaires and subscales for the total sample are summarized in Table 10. Internal consistency of the IUS-12 for the entire sample was excellent (α = .83). Overall, no gender differences were found regarding intolerance of uncertainty, $F(1,958) = 0.22$, $p = .64$. Regarding the subscales, no gender difference was found with respect to Prospective Anxiety, $F(1,958) = 0.83$, $p = .36$, but women scored significantly higher on Inhibitory Anxiety, $F(1,958) = 5.44$, $p = .02$. Both factors showed satisfactory internal consistency (α = .72 - .78).

3.3.2 Construct validity

Correlations between the IUS-12 and the other questionnaires were all highly significant (Table 10). Moreover, scores on the reduced IUS-12 were highly correlated with the 27-item version of the questionnaire (r = .92). The correlation between the IUS-12 and the PSWQ was significantly higher than the correlation between the IUS-12 and the STAI-T ($r_{IUS12\_PSWQ} > r_{IUS12\_STAI\text{-}T}$, Steiger $Z = 6.60$, $p < .01$). Both factors were more strongly associated with worry compared to anxiety (Prospective Anxiety: $r_{PA\_PSWQ} > r_{PA\_STAI\text{-}T}$, Steiger $Z = 5.03$, $p < .01$; Inhibitory Anxiety: $r_{IA\_PSWQ} > r_{IA\_STAI\text{-}T,}$ Steiger $Z = 4.64$, $p < .01$). No difference was found between r_{IUS12_PSWQ} and $r_{IUS12\_BDI\text{-}II}$ (Steiger $Z = 1.03$, *ns*), although Prospective Anxiety showed a stronger correlation with worry compared to depression ($r_{PA\_PSWQ} > r_{PA\_BDI\text{-}II}$, Steiger $Z = 2.04$, $p < .05$; Inhibitory Anxiety: $r_{IA\_PSWQ} = r_{IA\_BDI\text{-}II}$, Steiger $Z = -1.34$, *ns*).

A hierarchical regression analysis was performed to investigate the unique contribution of the IUS in the explanation of worry (PSWQ) (Table 11). In a first step, gender and age were included to control for demographical variables. Next, depression and anxiety

scores were entered. Finally, either IUS-12 or IUS-27 scores were added to the regression model. Results showed that intolerance of uncertainty significantly contributes to worry, above and beyond demographical variables and levels of anxiety and depression. Moreover, both versions of the IUS accounted for a similar proportion of the variance in worry scores (IUS-12: $\beta = .27$, $p < .001$, $R^2 = .51$, $\Delta R^2 = .06$; IUS-27: $\beta = .28$, $p < .001$, $R^2 = .50$, $\Delta R^2 = .05$).

Discriminant validity of the two subscales of the IUS-12 was investigated using multiple hierarchical regression analyses, successively using symptom measures for worry (PSWQ), anxiety (STAI-T), and depression (BDI-II) as criterion variables. In a first step, gender and age were entered to control for demographic variables. In a second step, the two other symptom measures were included. In a third step, PA and IA were added to the model. Results showed that PA explained unique variance in worry ($\beta = .23$, $p < .001$), whereas IA was uniquely associated with anxiety ($\beta = .12$, $p < .05$) and depression ($\beta = .34$, $p < .001$).

Table 10. Means (*M*), Standard Deviations (*SD*), Cronbach's alpha (α), number of participants (*N*), and Pearson inter-correlations of the Questionnaires

Variable	*M*	*SD*	α	*N*	2.	3.	4.	5.	6.	7.
1. IUS-12_PA	17.85	5.00	.78	967	.55**	.92**	.78**	.38**	.46**	.22**
2. IUS-12_IA	11.57	3.56	.72	967	1	.83**	.86**	.51**	.46**	.24**
3. IUS-12_total score	29.41	7.56	.83	967		1	.92**	.48**	.52**	.26**
4. IUS-27_total score	67.77	15.20	.90	967			1	.57**	.55**	.25**
5. BDI-II	10.44	7.05	.85	470				1	.54**	.12**
6. PSWQ	50.74	12.61	.92	521					1	.39**
7. STAI-T	48.92	4.81	.40	626						1

Note. IUS-12_PA = Prospective anxiety, IUS-12_IA = Inhibitory anxiety, IUS-12_total score = Intolerance of Uncertainty Scale short 12-item version, IUS-27_total score = Intolerance of Uncertainty Scale (full 27-item version), BDI-II = Beck Depression Inventory, PSWQ = Penn State Worry Questionnaire, STAI-T = trait version of the State Trait Anxiety Inventory.

** $p < .01$.

Table 11. Hierarchical regression analysis: Intolerance of Uncertainty significantly contributes to worry (PSWQ) above and beyond demographical variables and levels of depression and anxiety

Variables	R^2	ΔR^2	*B*	*SE B*	β
Step 1	.09***	.09***			
Gender			9.63	1.47	.30***
Age			0.14	0.16	.04
Step 2	.45***	.37***			
BDI-II			0.84	0.06	.47***
STAI-T			0.87	0.09	.33***
Step 3	.51***	.06***			
IUS-12			0.46	0.06	.27***
Step 3	.50***	.05***			
IUS-27			0.23	0.03	.28***

Note. IUS-12 = Intolerance of Uncertainty Scale (short 12-item version), IUS-27 = Intolerance of Uncertainty Scale (full 27-item version), BDI-II = Beck Depression Inventory, PSWQ = Penn State Worry Questionnaire, STAI-T = trait version of the State Trait Anxiety Inventory. R^2 = The proportion of variance accounted for by the model, ΔR^2 = Additional change in the proportion of variance accounted for by the model, *B* = regression coefficient ,*SE B* = standard error of *B*, *β* = standardized regression coefficient. *** p<.001.

4 Discussion

Previous studies investigating the validity of the IUS did not reveal univocal factor solutions. Hence, the purpose of the current study was to compare the different proposed factor structures of both the full and shortened Dutch version of the IUS in a sample of healthy undergraduate students and adults. Next, psychometric properties of the model with the best fit were investigated. Finally, invariance of this model across gender was examined.

CFA indicated that the IUS-12 model with the two factors Prospective Anxiety and Inhibitory Anxiety provided the best fit, corroborating earlier findings (Carleton, Norton, et al., 2007; McEvoy & Mahoney, 2011). Furthermore, the reduced measure had equally good internal consistency, accounted for similar proportion of the variance in worry scores, and was highly correlated with the 27-item version of the IUS. Internal consistency of both factors was good, providing support for the use of the two subscales separately. Considering the high internal consistency of the total score, however, the use of a total IU score is also justified.

Since intolerance of uncertainty is conceptualized as "cognitive, emotional and behavioural reactions to uncertainty in everyday life situations" (Freeston, et al., 1994, p. 792), it is likely that IU inherently consists of different dimensions, which are represented by different factors or subscales. Previous research (Carleton, et al., 2012) suggested that Prospective Anxiety tends to focus on the cognitive dimension of IU, whereas Inhibitory Anxiety captures the more behaviourally focused aspects of IU. The subscales are also considered to measure approach and avoidance tendencies respectively (Birrell, Meares, Wilkinson, & Freeston, 2011). The PA subscale comprises items that represent active seeking for information to reduce unpredictability (e.g. 'I should be able to organize everything in advance'), while the IA subscale includes items referring to paralysis of cognition and action in uncertain situations (e.g. 'When it's time to act uncertainty paralyses me'). Results of the current study indicated that both Prospective and Inhibitory Anxiety, as well as general IU (IUS-12) showed a stronger relation with worry (PWSQ) compared to trait anxiety (STAI-T). This suggests that IU is a more important factor for worry than for trait anxiety, and that it might even be a cognitive vulnerability factor for the development of persistent worry. These results differed from previous research (de Bruin, et al., 2006), using the total score of the IUS-27, in which no evidence was found for a difference between these correlations. Additionally, IU seemed to be equally related to worry (PSWQ) as to depression (BDI-II). However, when considering both factors separately, PA showed a stronger correlation with worry compared to depression, which is not surprising as PA comprises future-related fear and anxiety, whereas people suffering from depressive symptoms mainly tend to ruminate about the past or present (Ehring & Watkins, 2008; Nolen-Hoeksema, 1991). IA, on the other hand, might display considerable overlap with diminished activity, as observed in depression. In other words, worry, depression, and anxiety are all related to the IU construct, but the strongest overlap with IU was found for worry and depression. Another important finding with respect to the subscales in the current study was that PA turned out to explain unique variance in worry, whereas IA was uniquely associated with anxiety and depression, supporting prior research (McEvoy & Mahoney, 2011). These findings may yield implications for differentiated treatment.

The current study found that intolerance of uncertainty contributes to the prediction of worry, over and above demographical variables and levels of anxiety and depression, emphasizing its unique contribution concerning the prediction of worry. These findings are in line with previous research, which has demonstrated that IU is associated with worry and GAD (Laugesen, et al., 2003), and might even be a *causal* risk factor for pathological worry

and GAD (Dugas, et al., 2005). IU enables to distinguish GAD patients from non-GAD anxious individuals (Dugas, Freeston, et al., 1998; Ladouceur, et al., 1999), panic disorder patients with agoraphobia (Dugas, et al., 2005), and non-clinical controls (Ladouceur, et al., 1999). Several processes have been proposed concerning the mechanisms through which IU would give rise to pathological worry (Birrell, et al., 2011; Dugas, Buhr, & Ladouceur, 2004; Dugas, Gagnon, et al., 1998). First, IU might increase levels of positive beliefs about worry (e.g., worrying will lead to a solution), which in turn results in increased levels of worrying (Bredemeier & Berenbaum, 2008). Second, IU might give rise to negative problem orientation, disturbing appraisals of the problem (Koerner & Dugas, 2008) and problem solving abilities, due to lack of confidence. Subsequently, negative problem orientation interferes with actual problem solving, thereby increasing levels of worry and anxiety (Dugas, et al., 2004). A third putative process accounting for the association between IU and worry is cognitive avoidance (Dugas, Gagnon, et al., 1998). When focusing on linguistic thoughts, one can avoid presentation of mental images, which are considered unpleasant, and are shown to cause somatic arousal. However, this avoidance strategy might prevent emotional processing of the threatening situation, further increasing threat value of the images. This in turn may lead to the maintenance of worry. A fourth possible mediating mechanism is through an increase of perceived threat, which can be translated into overestimation of both the likelihood and negative consequences of negative outcomes (Bredemeier & Berenbaum, 2008; Chen & Hong, 2010; Dugas, et al., 2004).

However, IU is found be related to other pathologies as well. Research including clinical (Sica, et al., 2004; Steketee, Frost, & Cohen, 1998; Tolin, Abramowitz, Brigidi, & Foa, 2003) as well as non-clinical samples (Boelen & Reijntjes, 2009; Dugas, et al., 2001; Holaway, Heimberg, & Coles, 2006) has shown that IU may also be involved in obsessive compulsive disorder (OCD). Steketee et al. (1998) demonstrated that IU was a strong predictor for the severity of OCD symptoms. Tolin and colleagues (2003) argued that the relationship between IU and OCD was most prominent in patients displaying checking and repeating compulsions. Pathological doubt, being one of the core features of OCD, is most pronounced in individuals displaying checking rituals. Whereas decreased memory confidence might reflect the more cognitive component of pathological doubt, IU may represent the more emotional feature of pathological doubt in OCD patients (Tolin, et al., 2003). Furthermore, Boelen and Reijntjes (2009) reported that IU is not only related to symptoms of GAD and OCD, but that IU is also associated with social anxiety (SA). This corroborates findings by Carleton, Collimore, et al. (2010), who particularly demonstrated the

importance of the relationship between the Inhibitory Anxiety component of the IU construct and SA. Other pathologies that have been associated with IU are panic disorder (PD) (Dugas, Gagnon, et al., 1998; Dugas, et al., 2001; Tolin, et al., 2003), state anxiety (Chen & Hong, 2010; Greco & Roger, 2001), obsessive compulsive personality disorder (Gallagher, South, & Oltmanns, 2003), eating disorders (Konstantellou, et al., 2011; Sternheim, et al., 2011), and somatoform disorders (Boelen & Carleton, 2012; Deacon & Abramowitz, 2008). However, IU does not seem to be critical for depressive disorders (Boelen & Reijntjes, 2009; Dugas, Schwartz, & Francis, 2004).

Given that IU plays a central role in both the development and maintenance of several disorders (Carleton, Collimore, et al., 2010; Holaway, et al., 2006; Tolin, et al., 2003), targeting IU is likely to reduce symptoms as well. For instance, increasing non-clinical individuals' tolerance of uncertainty may help preventing the development of GAD (Dugas, et al., 2001). Moreover, research has indicated that cognitive-behavioural treatment targeting IU is effective in reducing excessive worry in GAD patients (Dugas & Ladouceur, 2000; Dugas, et al., 2003; Ladouceur, Dugas, et al., 2000), but also results in relief of SAD symptoms (Carleton, Collimore, et al., 2010; Mahoney & McEvoy, 2012), as many social-evaluative situations comprise a great deal of uncertainty (Boelen & Reijntjes, 2009). As mentioned earlier, individuals' scores on the subscales of the IUS may indicate which treatment strategies are most appropriate for a particular person (McEvoy & Mahoney, 2011). Individuals scoring high on Prospective Anxiety might benefit most from re-evaluation of erroneous beliefs about worry, whereas individuals with high Inhibitory Anxiety may profit more from specific cognitive-behavioural techniques such as problem orientation training and exposure to uncertainty (Birrell, et al., 2011; Dugas & Ladouceur, 2000; Ladouceur, Dugas, et al., 2000). The former technique implies focusing on the core issues of one's problems, as individuals with high intolerance of uncertainty often lose themselves in irrelevant details in an attempt to reduce uncertainty. Subsequently, participants are stimulated to proceed with the problem-solving process even if the outcome is unsure in advance. The latter technique involves exposure to threat-related and uncertain situations. Imaginary exposure can be used in addition to exposure in vivo in order to maintain therapeutic gains (Foa, Steketee, Turner, & Fischer, 1980). Application of such exercises might result in habituation to feelings of uncertainty, and enhancement of (perceived) self-efficacy to tolerate feelings of uncertainty (Tolin, et al., 2003). Furthermore, IU can be used as an outcome measure for treatment of several anxiety disorders (Carleton, Collimore, et al., 2010; Carleton, Gosselin, & Asmundson, 2010), since previous research has demonstrated that treatment outcome is

highly associated with changes in intolerance of uncertainty (Dugas & Ladouceur, 2000; Ladouceur, Dugas, et al., 2000).

Although the results of this study are promising, a few limitations need to be considered. First, the sample largely consisted of women (81.1%). Although no gender differences were found for IU in general, and factor solutions were consistent among both genders, women reported more Inhibitory Anxiety than men. Additionally, gender differences were found for the other measures (PSWQ, and BDI-II), with women scoring higher than men, supporting earlier findings (Bender, et al., 2006; Dugas, et al., 1997; Dugas, et al., 2001; Haba-Rubio, 2005; Stavosky & Borkovec, 1988). Second, only healthy individuals participated in the study. Consequently, the current findings may not generalize to clinical samples, although previous studies suggested that psychometric properties of the IUS were comparable in clinical and non-clinical samples (Dugas & Robichaud, 2007; McEvoy & Mahoney, 2011). Finally, one might consider adjusting the names of the subscales into Prospective and Inhibitory Intolerance of Uncertainty, as IU is proven to be a transdiagnostic concept, not specific to anxiety (Boelen & Carleton, 2012; Carleton, et al., 2012; McEvoy & Mahoney, 2011). Other possible labels arising from a recent review study (Birrell, et al., 2011) are Desire for predictability and an active engagement in seeking certainty, and Paralysis of cognition and action in the face of uncertainty respectively.

To summarize, the current study provided evidence for the utility of the shortened version of the IUS. These findings are in line with the results of Carleton et al. (2007), who examined the English version of this questionnaire. Additionally, the use of the two separate subscales might provide a steppingstone for successful treatment of different mental disorders. As a consequence, the application of the psychometrically sound IUS-12 should be encouraged in future research regarding intolerance of uncertainty.

CHAPTER VI:
General Discussion

Although there is accumulating research evidence supporting the Fear-Avoidance Model (FAM) in understanding how pain can interfere with daily life activities, literature on the acquisition of pain-related fear is scarce (Leeuw, et al., 2007). Three developmental pathways to pain-related fear have been proposed: Direct experience, verbal instruction, and observation. This dissertation aimed at establishing observational learning of pain-related fear and subsequent extinction through first-hand exposure to the feared stimuli in healthy individuals. Moreover, we explored whether observers' pain catastrophizing, trait fear of pain, negative affectivity, intolerance of uncertainty, and dispositional empathy were associated with facilitated acquisition of pain-related fear through observation of a peer encountering a painful event. A differential fear conditioning paradigm was used, showing video models displaying either painful (CS+ colour) or neutral (CS- colour) facial expressions in the presence of two coloured stimuli (observation phase). These stimuli were cold pressor tasks (Chapter II), cold metal bars (Chapter III), or warm water tasks (Chapter IV). Afterwards, both coloured stimuli with equal temperatures were presented directly to the participants (exposure phase). Learning effects were investigated, focusing on (1) self-reported pain-related fear, pain, and harmfulness (beliefs and cognitions), (2) psychophysiological responses (arousal), and (3) behavioural tendencies (Lang, 1968).

1 Summary of the findings

1.1 Pain-related beliefs and cognitions

Results revealed successful acquisition of self-reported pain-related fear in all studies (observation phase). Participants reported more fear with regard to the stimulus that was previously associated with the painful facial expressions (CS+) compared to the stimulus that was associated with models' neutral expressions (CS-). They also expected contact with this threatening stimulus to be more unpleasant, painful, and harmful. No differential effects on self-reported beliefs and cognitions were found after first-hand exposure to the stimuli in the studies using the cold metal bars and the warm water tasks (exposure phase) (Chapter III and Chapter IV, respectively). However, in the cold pressor (CPT) study (Chapter II), participants still reported more pain-related fear regarding the CS+ compared to the CS- CPT, although no

differences were found concerning pain unpleasantness or pain intensity. This is in contrast with the study of Arntz and Claassen (2004), who showed that fear beliefs increase pain intensity ratings during exposure. Possibly, the temperature of the CPT (10°C) was too aversive for our participants, because concurrent pain-ratings rapidly increased throughout both immersions. Concerning the cold metal bar study (Chapter III), differential expectations regarding the fear beliefs were immediately adjusted after the first trial. Throughout the repeated presentations of the metal bars, no habituation in self-report ratings was registered for pain-related beliefs and cognitions regarding every dependent variable in the first experiment, and for pain unpleasantness, pain intensity, and perceived harmfulness in the second experiment. The decrease in fear regarding the bars in general in this latter experiment might indicate that the adapted temperature of the bars (8°C) was indeed more ambiguous than the temperature used in the first experiment (-25°C). With respect to the WWT study (Chapter IV), expectancies immediately before the immersion were still different for the CS+ and CS- task, whereas immediately after the immersions, no differences in experience were reported between the two tasks. Apparently, one exposure trial was sufficient to counteract the differential learning effects.

The absence of differential effects during the exposure phase does, however, not provide evidence for an extinction effect with regard to pain-related beliefs and cognitions. In clinical practice, an extinction effect would show in lower pain-related fear beliefs after treatment compared to the start of the treatment. Hence, it is interesting to explore whether pain-related fear beliefs after exposure to the feared stimulus are on average lower than pain-related fear beliefs after watching the observation video clip. However, prudence is in order, since during acquisition, expectations were measured, whereas during exposure, actual experiences are examined. This makes direct comparison between the phases difficult. In the experiments with repeated exposure of the metal bars to participants' neck (Chapter III), it seems that not the negative appraisals regarding the CS+ have diminished after exposure, but rather the aversive beliefs concerning the CS- were enhanced. In clinical terms this would mean for instance that a person with an observationally acquired spider phobia who does not fear mice, is as afraid of mice as of spiders after direct contact with both spiders and mice. Consequently, we cannot conclude that we have found evidence for an extinction effect concerning pain-related cognitions in this experiment. Pain-related fear, pain unpleasantness, and pain intensity ratings after the CPT immersions (Chapter II) decreased for the CS+, but also increased with regard to the CS- task. Finally, when using a warm water task paradigm (Chapter IV), a decrease in pain-related fear and harmfulness was observed for the CS+ as

well as for the CS- task. With respect to pain unpleasantness and pain intensity, CS+ ratings at the end of the experiment were lower compared to the acquisition phase, while no differences between phases were found for the CS-. Accordingly, in this WWT experiment, evidence was found for extinction of pain-related fear beliefs. The absence of a difference in pain-related beliefs during exposure in the cold metal bar experiments (Chapter III) and the increase of fear with regard to the CS- in the CPT study (Chapter II) might be due to generalisation of the fear to the CS-, as both conditioned stimuli share several features (Meulders & Vlaeyen, in press). Furthermore, extinction or exposure may be more successful if different pathways are combined. If the experimenter or therapist, who occupies an expert position, verbally reassures the participant or patient that no harm or injury will follow, pain-related fear might extinguish more easily (Lovibond & Shanks, 2002). The possibility of combined learning pathways will be elaborated on later (see *2.3 Acquisition and extinction pathway combinations*).

Self-reported behavioural avoidance tendencies revealed that watching the video clips led to reduced willingness to touch the CS+ stimulus, but willingness increased again after first-hand exposure to both stimuli with ambiguous but equal temperatures, providing some evidence for fear extinction.

1.2 Psychophysiology: Skin conductance responses

Skin conductance responses (SCR) were measured in the two metal bar experiments throughout the exposure phase (Chapter III). Overall, skin conductance responses decreased throughout repeated exposures, showing that physiological responses attenuated easily with this fear-irrelevant stimuli, which is in line with previous research (Hygge & Öhman, 1978). In contrast to earlier findings regarding fear in general (Kelly & Forsyth, 2007a, 2007b; Olsson, et al., 2007; Olsson & Phelps, 2004), no differences in SCR in anticipation of direct contact with the bars were found in either experiment. Evidence for a difference in psychophysiological responding during contact with both metal bars was found only in the second experiment. This difference persisted throughout the exposure phase. It is, however, difficult to compare this latter finding with previous research, as in other paradigms no real shocks (Olsson, et al., 2007; Olsson & Phelps, 2004) or enriched CO_2 air (Kelly & Forsyth, 2007a) were administered during extinction.

1.3 Avoidance behaviour

The changes in pain-related beliefs and cognitions were associated with changes in only some behavioural patterns. Immersion latency time in the CPT and WWT studies were

similar for both stimuli, even after adjustment of the instruction, which might have been too peremptory in the CPT study (‘*Please immerse your hand into the liquid right now*’) compared to the WWT study (*‘Please immerse your hand whenever you feel ready’*) (Chapter II and Chapter IV, respectively). When using an indirect reaction time task, based on the compatibility between the valence of the stimulus and the response, no differences were found between the two stimuli in the metal bar study (Approach Avoidance Task, Chapter III), although in the WWT study, participants showed stronger avoidance tendencies with respect to the CS+ compared to the CS- task (Stimulus Response Compatibility task, Chapter IV). Furthermore, participants did not show a preference for the CS- CPT when they were asked which task they would prefer to repeat (Chapter II), but they did prefer the CS- WWT to the CS+ WWT (Chapter IV). A possible explanation for this is that the temperature of both CPT was too aversive, which was also suggested after analysing the self-report data.

These findings raise the question under which conditions observationally learned fear beliefs translate into avoidance behaviour. Several researchers underline the difference between learning and performance (Bandura, 1965; Fryling, Johnston, & Hayes, 2011; Goubert, et al., 2011; Greer, Singer-Dudek, & Gautraux, 2006). While learning is described as the ability to verbalize what was observed, performance refers to engaging in the observed behaviour, possibly at a later time. The processes underlying learning and performance might also differ. Whereas learning is associated with attention and retention processes, performance is believed to be mediated by motor reproduction and motivational processes (Fryling, et al., 2011). A possible reason for the absence of some hypothesized behavioural effects in the current studies, might be the (lack of) salience of the stimuli. One might expect that personal needs or relevance play an important role herein (Goubert, et al., 2011; Hermann, 2007). The laboratory setting may not have been threatening enough for the healthy participants, whereas for pain patients, impending pain is probably more salient, facilitating the translation of fear beliefs into overt behavioural avoidance. Moreover, the nature of the relationship between model and observer might have influenced the strength of the observational fear learning effect (Goubert, et al., 2011). Although observational learning effects are not restricted to observing intimate pain models, family or ‘in-group’ members are supposed to have a larger impact than strangers (Braaksma, et al., 2002; Platow, et al., 2008). Nonetheless, both the models and the participants in our study were young females, and the models were told to be students that participated earlier in the same study, hence belonging to the same in-group. Despite our effort to maximize identification with the models, they may still have been perceived as strangers. Furthermore, in these studies, we have only focused on avoidance

behaviours. It might be interesting to examine participants' communicative pain expressions (e.g., facial pain expressions) during actual exposure to the feared stimuli in future research (PrKachin, 1986).

1.4 Observer's characteristics

If we can identify individuals who are vulnerable to develop pain-related fear through observation, we can try to prevent or tackle this development in an early treatment stage by using techniques aimed at reducing this fear. In this dissertation, we focused on putative moderating influences of pain catastrophizing, trait fear of pain, intolerance of uncertainty, dispositional empathy, and negative affectivity. We hypothesized that individuals scoring higher on the aforementioned characteristics would be more prone to develop observationally acquired pain-related fear compared to participants scoring lower on these trait variables. More specifically, we expected that individuals with higher negative affectivity or high pain catastrophizers would experience a painful stimulus as more aversive. Individuals who are more intolerant of uncertainty and ambiguous situations are probably more sensitive to information that disambiguates a situation. In the context of this project, it means that we expected them to rely to a greater extent on the information that was obtained through the observation video. For participants with higher dispositional empathy, pain expressions of the video models might be perceived as more aversive.

Although, across all experimental studies, no consistent findings were found, some trends can be observed. In the CPT paradigm (Chapter II), the acquisition of pain-related fear beliefs was more pronounced in participants with higher negative affectivity. When using the coloured cold metal bars (Chapter III), dispositional empathy seemed to moderate the acquisition of pain-related beliefs and cognitions. The influence was especially due to the perspective taking (PT) and fantasy (FS) subscale characteristics. Differential effects emerged for participants with lower PT, who reported more fear, and expected more pain unpleasantness, intensity, and harm with respect to the CS+ compared to the CS- bar. Fantasy, on the other hand, was found to facilitate observational learning of pain unpleasantness and intensity. Finally, pain catastrophizing, intolerance of uncertainty, trait fear of pain, and dispositional empathy were associated with facilitated self-reported observational learning effects in the warm water task study (Chapter IV).

Pain catastrophizing can be defined as a negative cognitive-affective response to anticipated or actual pain (Quartana, Campbell, & Edwards, 2009), associated with pain severity, activity interference, disability, increased pain expressions, and illness behaviour in pain-free as well as in individuals suffering from chronic pain conditions (Peters, Vlaeyen, &

Weber, 2005; Quartana, et al., 2009; Vlaeyen, de Jong, Leeuw, & Crombez, 2004). Multidisciplinary pain treatment focusing on the reduction of catastrophic thoughts has been found to decrease pain intensity, disability, and depression (Jensen, Turner, & Romano, 2001). According to Sullivan and colleagues (2001), the influence of catastrophizing on pain experiences and disability is mediated by appraisals, such as pain-related fear beliefs. Moreover, catastrophizing has been found to enhance fear processing (Carroll, Conroy, & Jones, 2011), which is in line with the findings of our WWT experiment (Chapter IV).

Dispositional empathy is a multidimensional construct which can be described as "a sense of knowing the personal experience of another person" (Goubert, et al., 2005, p. 168). According to the Perception–Action Model of empathy (Preston & de Waal, 2002), the perception of a given state in another individual spontaneously triggers the corresponding representation of that state in the observer. Earlier studies showed that neural regions linked to empathy are also active during observational fear learning (Goubert, et al., 2005; Olsson, et al., 2007; Yamada & Decety, 2009), and that observers with higher empathy are more responsive to a placebo analgesia intervention after witnessing successful pain treatment (Colloca & Benedetti, 2009). Fitzgibbon et al. (2010) have found that the more one empathises with a model, the higher one's pain intensity and unpleasantness reports. Moreover, Mailhot and colleagues (2012) demonstrated that viewing pain in others facilitates pain-related fear responses. Surprisingly, observers with higher dispositional empathy showed a reduction of the observational facilitation of perceptual pain responses (pain intensity, pain unpleasantness), although the NFR (nociceptive flexion reflex) was not affected by prior observational learning (Mailhot, et al., 2012; Vachon-Presseau, et al., 2011). This was explained by the distinction between low level empathic processes (e.g., emotional contagion), which occur automatically during the first stage of a pain experience, and high level empathic processes (e.g., perspective taking and mentalizing), which are driven by higher cognitions and may lead to suppression of automatic defensive responses during the second stage of a pain experience (Valeriani, et al., 2008). Such down-regulation of self-protective responses enables highly empathic individuals to remove attention from their own discomfort, and to display prosocial behaviour. Hence, a potential explanation for the differential effects regarding PT on fear beliefs in low but not high PT in our studies (Chapter III) might be due to an attentional bias to others' emotional responses in individuals with high PT. This may have distracted them from the other stimuli presented in the video, which resulted in disturbed discrimination learning concerning the CS+ and CS- tasks.

Negative affectivity (NA) is a general dimension of subjective distress that subsumes a diversity of aversive mood states, including fear and anxiety (Watson, et al., 1988). The relationship between NA and pain experiences is not completely clear. In some studies, a link has been observed between NA and pain intensity. For instance, NA was found to lower the intensity at which pain is perceived as threatening, and to increase symptom reports in chronic pain patients (Leeuw, et al., 2007; Turk & Okifuji, 2002). However, in other studies, NA did not influence pain severity or disability (Gheldof, et al., 2010; Goubert, Crombez, & Van Damme, 2004). Furthermore, increasing evidence has been found for NA as a moderator in the development of pain-related fear, probably through attentional processes (Gheldof, et al., 2010; Linton, et al., 2000), which is in agreement with the findings of our CPT study (Chapter II), but was not demonstrated in the metal bar (Chapter III) or WWT studies (Chapter IV).

Hirsh et al. (2008) have found that higher trait fear of pain is associated with increased pain intensity ratings. The negative effect of fear of pain on pain reactions might be mediated by attention for pain-related material (Keogh, Ellery, Hunt, & Hannent, 2001). However, in the study of Roelofs et al. (2002), no relationship between fear of pain and attentional bias for pain words was found. Only in our WWT study (Chapter IV), evidence was found for a facilitating influence of trait fear of pain on pain-related fear, expected pain unpleasantness, expected pain intensity, and expected harmfulness. An alternative explanation is that individuals with higher trait fear of pain experience the unconditioned stimulus (US) as more threatening, resulting in a stronger conditioned response (CR).

The putative moderating influence of intolerance of uncertainty (IU) on an individual's pain experience has not been investigated so far, although a positive correlation was found between IU and pain-related fear (Carleton, Sharpe, & Asmundson, 2007). Both concepts imply fearing potentially harmful consequences. IU may also play a role in differentiating between subtypes of irritable bowel syndrome (IBS) (Keefer, et al., 2005), and has an influence on expectations concerning return to work in sub-acute back pain (Steward, Polak, Young, & Schultz, 2012). Intolerance of uncertainty is a concept that has been introduced fairly recently (Freeston, et al., 1994), and research concerning IU has mainly focused on its impact on anxiety disorders. However, as the results of our WWT study suggest (Chapter IV), IU might also modulate pain experiences. Individuals with higher IU might engage in a conditioned fear response at lower threshold compared to individuals with lower IU, because of a 'better safe than sorry' strategy. No adverse consequences follow if an ambiguous situation has mistakenly been categorized as threatening, whereas showing no fear responses in an ambiguous situation that might be threatening, is more likely to result in

negative consequences. Consequently, participants with higher IU are probably more sensitive to information from the video clips. In Chapter V, validity of the Dutch Intolerance of Uncertainty Scale (IUS) has been demonstrated. Results revealed that both the IUS-27 and the shortened IUS-12 are reliable measures. However, the two factor IUS-12 model provided the best fit, being invariant across gender. Hence, the use of this abbreviated questionnaire should be encouraged in future research.

Based on the results of our studies and recent literature findings, no clear conclusions can be drawn with respect to observers' moderating characteristics and pain experiences. Hence, more research needs to be undertaken before the role of observers' characteristics during observational (fear) learning in the context of pain is more clearly understood, since differences in dispositional characteristics might require a different treatment approach.

2 Fear learning pathways

2.1 Interactions between fear learning pathways

Evidence has been found for three main pathways in the acquisition of fear: Direct experience, verbal instruction, and observation (Rachman, 1977). Experimental research has mainly focused on the separate contributions of the three learning pathways to fear. However, learning experiences are likely to occur as a combination of different pathways (Mineka & Zinbarg, 2006). Recently, researchers started to investigate how multiple pathways might combine. Davey (1997) suggested in his conditioning model of phobias that learning through direct experience may be influenced by one's existing beliefs and prior threat information regarding the CS-US association. In addition, cognitive representations of the US may lead to US revaluation (inflation or devaluation), for instance through socially or verbally transmitted information concerning the US (Field & Davey, 2001; Muris & Field, 2010). In children, verbal threat information is found to facilitate subsequent learning through direct experiences, resulting in stronger avoidance behaviour compared to a verbal information alone or a direct experience alone condition (Field & Storksen-Coulson, 2007). Similarly, prior threatening information may facilitate observational fear learning (Askew, et al., 2008). Experimental studies investigating the impact of verbal information during as well as after vicarious modelling did not reveal enhanced learning effects. However, experimental manipulations in these studies may not have been powerful enough (Askew, et al., 2008). In the pain domain, animal research demonstrated that observational learning prior to a direct conditioning experience enhances pain-related fear learning (Bruchey, et al., 2010). In healthy humans,

observational learning is found to facilitate direct learning effects in the pain context. Godinho et al. (2006) demonstrated that presenting pictures showing human pain concurrently with direct painful stimulus presentation enhanced pain intensity ratings, even if arousal due to unpleasantness of the picture content was controlled for. When observational learning occurred prior to direct conditioning, increased pain intensity and pain unpleasantness was reported, and participants showed increased nociceptive flexion reflex (NFR) (Vachon-Presseau, et al., 2011). Facilitation was stronger when pictures displayed sensory pain information (painful stimulation of hand/foot) compared to emotional information such as painful facial expressions. Davey (1992) suggested that conditioned fear responses that have arisen as a consequence of learning through a combination of different pathways may be more resistant to extinction.

2.2 Three pathways to reduce pain-related fear

Since there are three pathways that may contribute to the acquisition of pain-related fear, one can assume that these pathways also play a role in the reduction of pain-related fear. In pain treatment programs, all three pathways are implemented in exposure in vivo therapy. Psycho-education (verbal instruction) may contribute to the reduction of pain-related fear, especially in patients with low back pain, who often benefit immediately from exposure in vivo therapy as a result from insight learning during the first sessions (de Jong, et al., 2012). A second stage in exposure treatment implies modelling of the feared behaviours by the therapist (observational learning) to demonstrate to the patient that no harm will follow as a consequence of these behaviours. Finally, patients are asked to perform the movements or behaviours themselves (direct experience) (den Hollander, et al., 2010).

2.3 Acquisition and extinction pathway combinations

The way in which an individual acquires pain-related fear might differ from the way in which this fear is reduced later on. Hence, different combinations of acquisition and extinction pathways are possible. Hygge and Öhman (1978) demonstrated that threat-reducing information after observational acquisition of pain-related fear is resistant to extinction if stimuli are fear-relevant, but does extinguish if fear-irrelevant stimuli are used. Olsson and Phelps (2004) have found that all three acquisition pathways lead to similar levels of fear learning, operationalized by skin conductance related to shock presentations. After all three learning conditions, participants underwent a direct extinction procedure in which no shocks (US) were delivered. Learning effects resisted extinction in all groups, with resistance being strongest after observational learning. In our experimental studies, observational acquisition

of pain-related fear was always followed by a direct experience extinction procedure. In contrast to pain patients, who might find a potentially painful stimulus more threatening and relevant, we expected the stimuli to be fear-irrelevant for our healthy participants. Therefore, we expected pain-related fear to extinguish throughout the extinction procedure. However, results differed depending on the stimuli that were used. In the studies involving the cold metal bars (Chapter III) and the warm water tasks (Chapter IV), no differences between the CS+ and CS- stimulus were found at the end of the experiment. In the cold pressor (CPT) study (Chapter II), on the other hand, participants still reported more fear with respect to the CS+ compared to the CS-, although the difference between CS+ and CS- was smaller than before the actual immersion. One possible explanation for this is that the CPT could have been experienced as more threatening compared to the other stimuli and as a result fear could have been more difficult to extinguish. The difference compared to the extinction procedure in the studies of Olsson and colleagues (extinction of the shock = model's US) was that in our experiments participants did perform a CPT, WWT or were actually touched by the metal bars with an ambiguous temperature (extinction of the model's emotional response = observer's US). Hence, they had first-hand experience with the feared stimulus, although this stimulus was hypothesized not to be as aversive as participants expected. The difference between the two types of experiments depends on the contingencies that are learned and extinguished. More information about contingency learning can be obtained under point 3 (*Contingency learning*).

Despite our effort to design an experiment with an observational acquisition phase followed by a direct experience extinction phase, participants might have experienced the 'extinction' phase as a prolonged non-differential acquisition of pain-related fear. For instance, in the metal bar experiment (Chapter III), both metal bars may have been associated with the cold properties of being in contact with the bars, irrespective of the colour and the preceding differential observational learning phase. The properties of the metal bars are the only US that are present during this second phase, being the same for both bars due to equal temperatures. This would mean that experiential knowledge has a stronger effect on pain-related fear compared to observational learning. This could explain the absence of a difference between the two bars and the absence of habituation throughout exposure. To investigate the possibility that the absence of the expected habituation during repeated exposure to the metal bars was caused by the observational acquisition of pain-related fear preceding the direct exposure (observational facilitation of direct experience learning), one

could examine whether there is habituation throughout repeated exposures of metal bar presentations when no observational acquisition is provided in advance.

Future research could concentrate on all different combinations of fear acquisition and extinction learning. Olsson et al. (2004) have found that the three separate developmental pathways yield similar fear acquisition effects, but no studies have been conducted on the comparison of different extinction pathways. An interesting question could be whether similar results are attained when observational acquisition is followed by observational extinction. In such a design, the video models perform the CS+ task in the exposure phase without showing a painful facial expression. Is the observational extinction pathway strong enough to result in fear reduction after observational acquisition? Possibly, participants with high negative affectivity have difficulties trusting this newly acquired information and will show longer resistance to extinction of pain-related fear. Similarly, participants with high intolerance of uncertainty receive inconsistent information through the observation video in the two phases, which could increase uncertainty and maintain fearful responses throughout the exposure phase ('better safe than sorry'). Another idea is to add verbal threatening information after observation of the video clips and compare it with a group that did not receive such information. This is an example of US inflation after observational acquisition of pain-related fear. With this paradigm, we could examine whether learning effects are stronger when an observational and instructional pathway are combined. In addition, we could investigate whether reduction of pain-related fear is harder to establish when different pathways have led to the acquisition of fear, as suggested by Davey (1992). A possible threat manipulation that has successfully been used with regard to pain-related fear acquisition in the past is: 'Exposure to cold water can lead to freezing in the long term' in combination with 'Your blood pressure is rather high but just within the limits to allow participation to the cold water procedure' (Van Damme, et al., 2008; Vlaeyen, et al., 2009). Additionally, colour changes and tingling sensations, which are harmless, normal CPT effects may be labelled as beginning frostbite symptoms (Vlaeyen, et al., 2009). The effect of different separate or combined extinction pathways can then be explored. For instance, during the extinction phase, participants might be told that the information about the blood pressure and possible frostbite was false before immersing their own hand into the cold water. These instructions may be accompanied by video clips showing models who do not express pain during the immersions or by direct exposure to the cold water task with water at room temperature. A third possibility for future research is reversing the pathways of the current studies. What happens when observational learning is preceded by direct experience (pre-exposure)? One could

expect that experiential learning is the strongest learning pathway (Lovibond, 2011). Hence, a differential observational phase is assumed not to succeed in disconfirmation of expectations or beliefs based on prior experience with the stimuli of equal temperatures. In addition, prior non-aversive pre-exposure is found to hamper fear acquisition after an aversive experience (Kent, 1997). However, mere direct exposure to a stimulus did not counter observational fear acquisition regarding snake or spider toys in children (Egliston & Rapee, 2007). Moreover, Asch' (1956) conformity experiments revealed that participants may adjust their answers to a majority of models, even if they had a different opinion than the models. They felt the models knew something they did not (informational social influence), and observing them made participants uncertain about their own perception. Again, this combined acquisition of pain-related fear pathways might be followed by separate or combined extinction pathways.

After scrutinizing acquisition and extinction of pain-related fear, research could focus on possibilities of relapse after successful extinction of fear. Extinction does not involve unlearning of a particular CS-US association, but embodies learning of a new inhibitory association between the same CS and US (Field, 2006). This inhibitory association is experienced as an exception to the general rule, which makes it difficult to generalize to other contexts or situations (den Hollander, et al., 2010). Hence, pain-related fear might suddenly return through reinstatement, renewal, or spontaneous recovery (Dirikx, Vansteenwegen, Eelen, & Hermans, 2009; Effting & Kindt, 2007; Rescorla, 2004, respectively). In the context of pain, spontaneous recovery is described as return of pain-related fear after a certain period of time, without any indication or presentation of the former CS (e.g., an activity) or US (e.g., pain). If extinction occurred in a different context than the acquisition of pain-related fear, exposure to the CS in the original or a new context may be sufficient to provoke fear, even in the absence of a current pain experience (US) (renewal effect). Finally, reinstatement is a phenomenon by which mere presentation of the US re-establishes the original CS-US relationship, resulting in a conditioned pain-related fear response. This mechanism is often observed in patients with chronic pain problems, as they are likely to encounter more painful experiences (US) in the future. Furthermore, after successful extinction of pain-related fear concerning movements that used to be associated with pain (e.g., climbing up the stairs, or lifting a crate), fear might pop-up again when this movement has to be performed in a context that was not implicated in the exposure treatment.

2.4 Other factors involved in pain-related fear acquisition? A non-associative pathway and neo-conditioning factors

Although evidence has been found for the existence of experiential, observational and instructional pathways in the development of fears (King, et al., 1998; Ollendick & King, 1991), many subjects are unable to recall the origin of their fear or phobia, or report to have always been fearful (Menzies, 1996). This raises the question whether conditioning is necessary in the development of fear. Several researchers proposed that an aversive association between a CS and a negative outcome (US) is not necessary for fear to arise (Poulton & Menzies, 2002; Rachman, 1991). Poulton and Menzies (2002) suggested that conditioning is present in the origin of evolutionary-neutral fears (e.g., dental fear), but it is not a necessary feature in the development of fear for evolutionary-relevant stimuli (e.g., snake fear). These latter fears are considered innate and can be acquired in the absence of prior associative learning experiences, leading to the introduction of a fourth pathway to fear, namely the non-associative pathway (Poulton & Menzies, 2002). A clear illustration is the visual cliff paradigm (Gibson & Walk, 1960), that provided evidenced for height fear from the day of birth, as no single chick, lamb or goat ever crossed the optical chasm.

However, there are several problems with the non-associative fear learning account (Davey, 2002; Kleinknecht, 2002; Merckelbach, de Jong, Muris, & van den Hout, 1996; Mineka & Öhman, 2002). Merckelbach et al. (1996) have found substantial evidence for conditional acquisition of spider phobia, which according to the non-associative account is a typical innate biologically-relevant fear. In addition, lab-reared monkeys, in contrast to wild-reared congeners, did not show fear during the first encounter with a snake (Mineka & Öhman, 2002). Furthermore, Davey (2002) argues that the fourth learning pathway might be non-specific rather than non-associative. For instance, 40 to 90% of spider and snake phobics are unable to report a specific event that caused their fear. Moreover, non-associative and conditional interpretations may be explained at different levels. Poulton and Menzies' theory (2002) offers an ultimate explanation of fear development, emphasizing the adaptive and protective function, whereas conditioning explanations are situated at a proximal level, stressing the underlying mechanisms leading to fear or phobias (Davey, 2002). Hence, both types of interpretations are not mutually exclusive (Davey, 1995).

Modern conditioning theories suggest that threat-related CS-US associations might arise without aversive conditioning experiences (Davey, 2002; Rachman, 1991). Neo-conditioning factors are based on contingencies and predictive value rather than CS-US contiguity (Menzies & Parker, 2001; Rachman, 1991). Whether or not an individual develops

fear may depend on one's learning history (Field, 2006). Prior non-aversive exposure to the CS might protect an individual from developing fear to the same CS when it is paired with an aversive stimulus (US) later on (latent inhibition) (Lubow, 1998). For example, an aversive encounter with the dentist is less likely to result in the acquisition of fear in children who have had many prior non-aversive visits to the dentist compared to children who have had less (Kent, 1997). Hence, a traumatic experience not always leads to the origin of fear (Merckelbach & Muris, 2001; Mineka & Zinbarg, 1996). Post-event factors might also have an impact on whether or not fear arises. An important cognitive process in this perspective is US revaluation (Davey, 1997; Mineka & Zinbarg, 1996; White & Davey, 1989), which can be described as intensification or attenuation of an aversive response without the presence of the predictive cue (CS). Revaluation may also take place after observational or instructional evaluative transmissions about the threat value of the US (Merckelbach, de Jong, et al., 1996). In the context of pain, this might mean for example that when a particular movement (e.g., bending) is associated with mild but not traumatic pain, followed by observation of a person expressing a lot of pain when performing the same movement, threat value of that movement increases, possibly resulting in fear. If generalisation of this fear occurs towards other movements, this may eventually lead to kinesiophobia. Possible mechanisms that may underlie the US revaluation process are catastrophic misinterpretation of bodily sensations and vulnerability factors such as disgust sensitivity, which is often observed in animal fears and phobias (Davey, 2002; Ehlers, 1991; Matchett & Davey, 1991). Finally, mental rehearsal of the CS-US association can result in fear inflation (Davey & Matchett, 1994). In the current studies, none of the participants had prior experience with the presented stimuli. During immersions (Chapter II and Chapter IV), participants had time to cognitively revaluate threat value of the stimuli, while in the metal bar experiment (Chapter III) we tried to avoid the possibility of US revaluation by presenting each stimulus for a very short time, asking to evaluate the experience immediately after every presentation.

Another category of factors that might influence fear acquisition are temperamental vulnerabilities. Three characteristics that have been associated with facilitated fear acquisition are high trait anxiety, general neuroticism, and introversion (Davey, 1997; Mineka & Zinbarg, 2006; Rachman, 1991). In the current dissertation investigating *pain-related* fear, trait fear of pain, which is related to trait anxiety (Roelofs, et al., 2002), and intolerance of uncertainty, which shows considerable overlap with neuroticism (McEvoy & Mahoney, 2011), moderated fear learning under certain conditions. Furthermore, contextual variables may impact on fear learning (Merckelbach, de Jong, et al., 1996; Mineka & Zinbarg, 2006). Fear is more easily

established if the aversive event is perceived as unpredictable or uncontrollable (Fonteyne, Vervliet, Hermans, Baeyens, & Vansteenwegen, 2009). In the metal bar experiments (Chapter III), participants had no control over the presentation of the bars to the neck, which could have facilitated fear acquisition, whereas in the CPT (Chapter II) or WWT (Chapter IV) studies, participants had control over the starting time of the immersion, and they were able to withdrawal their hand from the water. Nevertheless, clear acquisition of pain-related fear beliefs was obtained in all experiments. Moreover, culturally transmitted information may affect the content and display rules of fears and phobias (Merckelbach, de Jong, et al., 1996; Mineka & Zinbarg, 2006). From a very young age, information regarding fears is transferred through fairy tales (Field & Davey, 2001). Examples of such stories are 'Little miss Muffett' (spider phobia), 'Little red reading hood and the big bad wolf' (fear of dogs), 'Cinderella' or 'Snowwhite' (fear of stepmothers), and the 'Goosebumps' book series (fear of ghosts and dead things). In addition, actions that are considered painful in some cultures may be perceived as normal initiation or transitional rituals in other cultures, where it might be paired with feelings of pride instead of fear. For instance, in particular Asian countries, men are being pierced with big hooks lifting their body from the ground. This 'Bagat' ritual is associated with a status increase but provokes pain-related fear in most Western citizens.

To summarize, conditioning or associative learning is found to be a useful framework to investigate different fear learning pathways (Brown & Brüne, 2012; Field, 2006). In this dissertation, the effect of observational acquisition and direct exposure was scrutinized. Future studies may elaborate on learning effects as a consequence of different pathway combinations during acquisition as well as during extinction. So far, only two studies have investigated combined fear learning pathways in the context of human pain (Godinho, et al., 2006; Vachon-Presseau, et al., 2011). The effect of observation concurrent or prior to direct painful stimulation was found to increase pain intensity and pain unpleasantness. No studies have examined the effect of combined pathways on the acquisition or extinction of pain-related *fear*.

3 Contingency learning

3.1 Associative learning

Associative learning can be conceptualized on three different levels: (1) as a procedure (the way of presenting relations between events or stimuli and registering responses), (2) as an

effect (a change in behaviour caused by a change in the relations in the environment), and (3) as a theory (the theoretical processes proposed to be responsible for the effect) (De Houwer, 2007). Associative learning is best defined as an effect, because it allows theoretical freedom concerning the possible psychological processes that underlie associative learning effects, and it helps to organize and compare research (De Houwer, 2009). Consequently, three questions can be asked: (1) *whether* behavioural changes are observed after changes in relations between events or stimuli are present, (2) *when* the procedure leads to associative learning effects (generality of associative learning), and (3) *how* associations lead to behavioural changes (conditions). Possible conditions that modulate associative learning as an effect are CS-US relationship awareness, attentional sources, goals, and dispositions (De Houwer, 2009; De Houwer & Barnes-Holmes, 2010). Contemporary learning models conceptualize associative learning as "the storage of propositional knowledge in memory" (Lovibond, 2011; Vlaeyen, et al., 2012, p. 33). Propositions are non-automatically generated and evaluated statements about the way in which objects or events are related (e.g., stimulus A *causes* outcome B), and help individuals to predict future events (De Houwer, 2009). According to the propositional account, learning is the consequence of the interaction between controlled propositional reasoning processes and automatic learning processes such as memory retrieval and perception (Mitchell, et al., 2009). One of the conditions under which associative learning effects may occur is contingency awareness (De Houwer, 2009), which will be explained in the following paragraph.

3.2 Contingency awareness

The majority of previous research has indicated that contingency knowledge is necessary for (differential) fear conditioning (De Houwer, 2012; Hoffman, De Houwer, Perugini, Baeyens, & Crombez, 2010; Lovibond & Shanks, 2002; Mitchell, et al., 2009; Tabbert, et al., 2011). Reliable and valid measures of awareness focus on contingency awareness and US expectancy. Contingency awareness is the awareness of the predictive CS-US relationship, while US expectancy is the awareness that the US is expected when the CS is presented without inferences of causality (Lovibond & Shanks, 2002). Awareness is preferably investigated concurrently during CS presentation (US expectancy) or between conditioning trials (verbalized CS-US hypotheses). Post-experimental interviews are also possible, with recognition tests being better than free recall tasks, but caution is in order when an extinction phase followed the acquisition phase, because extinction may interfere with contingency knowledge (Lovibond & Shanks, 2002).

In the current experiments, two different types of contingencies could have been learned. *First*, a directly experienced association could have been learned between the colour of the stimulus (CS) and the painful facial expressions of the video models (primary US). This way, the colour has become a predictor for the facial expression of the model. *Second*, an indirectly experienced contingency could have been obtained between the colour of the stimulus (CS) and the assumed properties of the task, namely being cold, warm or painful (secondary US). In order to find evidence for observational learning, the indirectly experienced relationship should have been learned (Goubert, et al., 2011). From the experimental studies using the CPT (Chapter II) and metal bars (Chapter III), we could not conclude that this latter relationship had been learned, although participants performed well on the categorisation task.

Therefore, in the WWT experiment (Chapter IV), we intended to manipulate the contingencies that were acquired while watching the observation video clips, using an open versus closed cover condition for the WWT (see *Figure 11*). We expected learning effects to be most pronounced in the condition with the open cover, as participants observed contact of the model with the coloured liquids, which would provoke learning of both the 'CS – primary US' and the 'CS – secondary US' contingency. In the closed cover condition, only the 'CS – primary US' contingency was hypothesized to be learned. Participants performed a recognition task at the end of the experiment, showing black-and-white pictures of the facial expressions of the video models in each video clip. They were requested to divide these pictures into two categories: One category was associated with the pink, the other with the orange WWT. Afterwards, they were asked which criterion they had used to categorise the pictures. As expected, the 'CS – primary US' contingency was learned in both conditions. Surprisingly, no differences were found between both conditions concerning the 'CS – secondary US' contingency, suggesting that observational learning had occurred in both conditions. This rather unexpected result may be understood by the categorisation task that was performed at the end of the experiment, so after participants' own immersions, which might have interfered with participants' contingency knowledge (Âsli, Kulvedrøsten, Solbakken, & Flaten, 2009; Lovibond & Shanks, 2002). Another possible explanation is that in both conditions steam was rising from the coloured CS+ WWT, which happened in order to keep both videos as similar as possible. However, participants might have attributed the steam in the video in the CS+ closed condition to aversive properties of the coloured liquid, causing the painful facial expression of the video model. With the US expectancy ratings, which were introduced immediately before each video fragment, only the awareness of the 'CS – primary

US' contingency could be demonstrated (*'To which degree do you expect to see a painful facial expression in the following video clip'*). Although the absence of a difference in contingencies that were learnt between the two conditions may not be due to the categorisation measure presented at the end of the experiment, future studies might try to make use of contingency awareness measures that can be completed immediately after the acquisition phase.

4 Expansion of the Fear-Avoidance Model

In the following paragraphs, the findings of this dissertation are being framed within the biopsychosocial fear-avoidance model (FAM), suggesting ideas for future research.

Previous research has highlighted the importance of pain-related fear in the origin of pain-related disability (Gheldof, et al., 2010; Leeuw, et al., 2007; Wideman, Adams, & Sullivan, 2009), but the development of pain-related fear has been investigated insufficiently. Vlaeyen and Linton (2012) proposed to expand the fear-avoidance model, examining stimulus topography, protective behaviours, and possible pathways to pain-related fear. In this dissertation, one of the three proposed informational sources to pain-related fear, namely the observational learning pathway, was scrutinized. Observation of pain in others clearly led to the acquisition of pain-related fear beliefs, which under certain conditions were translated into behavioural and psychophysiological changes. Although the results of this dissertation provide a useful addition to FAM, several issues remain to be investigated.

Pain and other pain-related factors of FAM such as pain-related fear do not occur in isolation. Consequently, several researchers have started extending FAM with contextual and motivational factors (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012; Vlaeyen & Linton, 2012). How individuals react to painful experiences may depend on personally valued functional goals (den Hollander, et al., 2010). For instance, when a non-pain-related goal is highly important, one might try harder to function despite the pain (Crombez, et al., 2012). Furthermore, FAM fails to explain task persistence and overuse, which is often observed in patients suffering from work-related upper extremity pain or fibromyalgia (Hasenbring & Verbunt, 2008; Vlaeyen & Morley, 2004). The Mood-as-Input model may therefore provide a fruitful addition, explaining task performance as a consequence of the interplay between mood, pain, and one's action goals (Vlaeyen & Morley, 2004, 2009). Moreover, Morley and Eccleston (2004) introduced the 'Identity' concept as a supplement to FAM, describing different pain consequences. Acute pain can interrupt on-going behaviour, and when persisting, it may interfere with daily life activities. As a consequence of chronic pain, even

identity changes might occur. Despite these different supplements to FAM being scrutinized in experimental as well as clinical studies, further research on the dynamic and sequential relationships of FAM factors within a motivational framework is desirable (Turk & Wilson, 2010; Wideman, et al., 2009).

5 Clinical relevance: Treatment and prevention

The current findings may have implications in the context of clinical pain, although we have to be cautious in generalizing these results to a clinical population. The reduction of pain-related fear is often associated with a decrease in pain and disability reports (Hirsh, et al., 2008). Hence, it might be an advisable factor to target in pain treatment programmes. Some individuals may benefit more from treatment targeting pain-related fear than others, due to temperamental vulnerabilities that facilitate the acquisition of pain-related fear (De Peuter, et al., 2009). Early screening may help identifying individuals who are most prone to develop pain-related fear, for instance by observing pain in other patients. Such a triage might be a useful, cost-effective, non-time consuming method to optimize individual treatment outcome.

Moreover, health care professionals should be aware of their attitudes regarding pain and pain-related fear, as patients might take over these attitudes through observation and verbal instructions (Darlow, et al., 2012; Houben, et al., 2005; Linton, et al., 2002; Ostelo & Vlaeyen, 2008). Implementing knowledge about pain-related fear and observational learning in acute pain situations might be appropriate, because prevention interventions concerning pain-related fear may avert transition from acute to chronic pain. For example, meeting recovered pain patients who suffered from similar injuries might reduce pain-related fear acquisition. In addition, previous research has indicated that pain-related fear reduction in an early stage of low back pain increases participation in physical activity despite the pain, limiting negative consequences in daily life (Swinkels-Meewisse, et al., 2006). Furthermore, family members of pain patients can be involved in psycho-educational treatment sessions explaining observational learning processes and possible maintaining factors concerning pain, since these individuals often observe their family member in pain, which may increase their own vulnerability for pain, avoidance and disability later in life (Vlaeyen & Crombez, 1999).

Many chronic pain patients suffer from pain-related fear, which can be even more disabling than the pain condition itself (Crombez, et al., 1999; Grotle, et al., 2004). Since pain-related fear can be extinguished after direct contact to the feared stimulus, exposure therapy, during which pain patients perform feared movements despite pain, is a promising behavioural treatment reducing excessive fears and avoidance behaviours and increasing

quality of life (Bailey, et al., 2010; de Jong, et al., 2012; Vlaeyen, et al., 2001; Vlaeyen, et al., 2012). Other pathways aimed at the reduction of pain-related fear are also implemented in exposure in vivo therapy (den Hollander, et al., 2010). During psycho-education, accurate verbal information is transmitted regarding one's pain problem, and often the therapist demonstrates the activity the patient is going to perform afterwards (positive modelling).

A specific technique that may be applied during pain treatment in order to reduce fear is US devaluation (Davey, 1997; Field, 2006). The therapist reassures the patient that no harm will follow as a consequence of a particular activity. Thereupon, threat value of the activity diminishes (Lovibond & Shanks, 2002), reducing fear of pain. In case of pain caused by a biomedical condition, such a technique should be applied as soon as possible after injury or surgery. Furthermore, cognitive reappraisal is employed to adjust erroneous beliefs (Lovibond, 2011). Beneficial effects are strongest if these beliefs are challenged by behavioural experiments as well. Finally, coping strategies that neutralize the US threat value (Field & Davey, 2001) and spouse assisted coping skills trainings, as observed in osteoarthritis patients' treatment (Keefe, et al., 1996), might reduce fear of pain through mechanisms of self-efficacy and feelings of control.

6 Limitations

There are several limitations to the current studies, which yield implications for future research. The most important limitation lies in the sample used in these experiments. Only healthy, young females participated in the study, which restricts ecological validity, and makes generalisation to male and patient populations difficult. Additionally, pain information may be transmitted more easily through same-gendered models (Goubert, et al., 2011; Hermann, 2007). In the current studies, both models and observers were female. Women are more prone to develop chronic pain, and are also known to report having more pain models, who are mostly female (Koutantji, et al., 1998). Nevertheless, it would be interesting to investigate whether results are similar when models and observers are of the opposite sex.

Another limitation might be the measure that was used to examine psychophysiological responding. Startle response (EMG) might be a better measure than skin conductance responses to use in future experiments because it is more specifically related to fear, whereas skin conductance is a measure for general arousal (Vrana, et al., 1988). In addition, it has been used successfully in experimental fear of pain studies (Meulders, et al., 2011).

An issue that was not addressed in the current studies, was the possible impact of cognitive strategies on an individual's pain experience. During CPT and WWT immersions (Chapter II and Chapter IV, respectively), participants had considerable time to revaluate their current experience, for instance with regard to previous similar experiences, or prior information from others. Another strategy that may have been used by participants in an attempt to reduce their pain is distraction (Verhoeven, et al., 2010). For example, one could try to move attention away from the pain task to other stimuli in the environment, or to go through different activities one has planned during the following days. Hence, further research might investigate which cognitive strategies participants apply during immersions.

A final limitation concerning the ecological validity of the study lies in the isolated examination of the observational learning pathway in the acquisition of pain-related fear. In real life, fear of pain is likely to be obtained through a combination of different learning pathways. Only a few studies have been conducted regarding the effect of combined fear learning pathways on pain intensity ratings, but no research has been done with respect to pain-related fear. This certainly merits further attention.

7 Conclusion

Despite the aforementioned limitations, the findings of these studies provide evidence for the importance of the observational learning pathway in the origin of pain-related fear. Several variations of a differential fear conditioning paradigm were explored in order to create an ambiguous situation in which participants had to extract information from the environment, in this case the observational video clips, to disambiguate the situation by inferring properties of a task from models' facial pain expressions.

Observationally acquired pain-related fear beliefs did, however, not always result in changes in behaviour or changes in psychophysiological responses. Ideas about the conditions under which these beliefs translate into overt behavioural changes have been suggested. Moreover, further research is needed to identify possible temperamental vulnerability factors that might be a point of departure for individualized treatment.

To summarize, the results of this project not only enhance our understanding of the acquisition of pain-related fear, it may also have implications for the development of prevention and cognitive-behavioural management strategies for patients with chronic pain.

ACKNOWLEDGEMENTS

This research project was supported by the Odysseus Grant "the Psychology of Pain and Disability Research Program" funded by the Research Foundation – Flanders (FWO Vlaanderen, Belgium).

REFERENCES

Arbuckle, J. L. (2010). *IBM SPSS Amos 19 user's guide*. Chicago: SPSS.

Arntz, A., & Claassens, L. (2004). The meaning of pain influences its experienced intensity. *Pain, 109*(1-2), 20-25.

Asch, S. E. (1956). Studies of independence and conformity: A minority of one against an unanimous majority. *Psychological Monographs, 70*, 416.

Askew, C., & Field, A. P. (2007). Vicarious learning and the development of fears in childhood. *Behaviour Research and Therapy, 45*, 2616-2627.

Askew, C., & Field, A. P. (2008). The vicarious learning pathway to fear 40 years on. *Clinical Psychology Review, 28*, 1249-1265.

Askew, C., Kessock-Philip, H., & Field, A. P. (2008). What happens when verbal threat information and vicarious learning combine? *Behavioural and Cognitive Psychotherapy, 36*, 491-505.

Âsli, O., Kulvedrøsten, S., Solbakken, L. E., & Flaten, M. A. (2009). Fear potentiated startle at short intervals following conditioned stimulus onset during delay but not trace conditioning. *Psychophysiology, 46*(4), 880-888.

Asmundson, G. J. G., Norton, P. J., & Norton, G. R. (1999). Beyond pain: The role of fear and avoidance in chronicity. *Clinical Psychology Review, 19*(1), 97-199.

Asmundson, G. J. G., Norton, P. J., & Vlaeyen, J. W. S. (2004). Fear-Avoidance Models of Chronic Pain: An Overview. In G. J. G. Asmundson, J. W. S. Vlaeyen & G. Crombez (Eds.), *Understanding and Treating Fear of Pain*. Oxford: Oxford University Press.

Bailey, K. M., Carleton, R. N., Vlaeyen, J. W. S., & Asmundson, G. J. G. (2010). Treatments addressing pain-related fear and anxiety in patients with chronic musculoskeletal pain: A preliminary review. *Cognitive Behaviour Therapy, 39*(1), 46-63.

Bandura, A. (1965). Influence of model's reinforcement contingencies on the acquisition of imitative responses. *Journal of Personality and Social Psychology, 36*, 589-595.

Bandura, A. (1986). *Social foundations of thought and action: A social-cognitive view*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A., Ross, D., & Ross, S. A. (1961). Transmission of aggressions through imitation of agressive models. *Journal of Abnormal and Social Pychology, 63*, 575-582.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Belzer, K. D., D'Zurilla, T. J., & Maydeu-Olivares, A. (2002). Social problem solving and trait anxiety as predictors of worry in a college student population *Personality and Individual Differences, 33*(4), 573-585.

Bender, C. M., Sereika, S. M., Berga, S. L., Vogel, V. G., Brufsky, A. M., Paraska, K. K., et al. (2006). Cognitive impairement associated with adjuvant therapy in breast cancer. *Psycho-Oncology, 15*, 422-430.

Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin, 107*, 238-246.

Berger, S. M. (1962). Conditioning through vicarious instigation. *Psychological Review, 69*(5), 450-466.

Bieling, P. J., Antony, M. M., & Swinson, R. P. (1998). The State-Trait Anxiety Inventory, Trait version: structure and content re-examined. *Behaviour Research and Therapy, 36*, 777-788.

Birrell, J., Meares, K., Wilkinson, A., & Freeston, M. H. (2011). Toward a definition of intolerance of uncertainty: A review of factor analytical studies of the Intolerance of Uncertainty Scale. *Clinical Psychology Review, 31*, 1198-1208.

Boelen, P. A. (2010). Intolerance of uncertainty and emotional distress following the death of a loved one. *Anxiety, Stress, and Coping, 23*(4), 471-478.

Boelen, P. A., & Carleton, R. N. (2012). Intolerance of uncertainty, hypochondriacal concerns, obsessive-compulsive symptoms, and worry. *The Journal of Nervous and Mental Disease, 200*(3), 208-213.

Boelen, P. A., & Reijntjes, A. (2009). Intolerance of uncertainty and social anxiety. *Journal of Anxiety Disorders, 23*, 130-135.

Boersma, K., & Linton, S. J. (2005). Screening to identify patients at risk: profiles of psychological risk factors for early intervention. *Clinical Journal of Pain, 21*, 38-43.

Bollen, K. A., & Long, J. S. (Eds.). (1993). *Testing structural equation models*. Newbury Park, CA: Sage.

Bouton, M., Mineka, S., & Barlow, D. H. (2001). A contemporary learning theory perspective on the etiology of panic disorder. *Psychological Review, 108*, 4-32.

Braaksma, M. A. H., Rijlaarsdam, G., & van den Bergh, H. (2002). Observational learning and the effects of model-observer similarity. *Journal of educational psychology, 94*(2), 405-415.

Bredemeier, K., & Berenbaum, H. (2008). Intolerance of uncertainty and perceived threat. *Behaviour Research and Therapy, 46*, 28-38.

Breivik, H., Collett, B., Ventafridda, V., Cohen, R., & Gallacher, D. (2006). Survey of chronic pain in Europe: Prevalence, impact on daily life, and treatment. *European Journal of Pain, 10*, 287-333.

Britton, J. C., Lissek, S., Grillon, C., Norcross, M. A., & Pine, D. S. (2011). Development of anxiety: The role of threat appraisal and fear learning. *Depression and Anxiety, 28*, 5-17.

Broeren, S., Lester, K. J., Muris, P., & Field, A. P. (2011). They are afraid of the animal, so therefore I am too: Influence of peer modeling on fear beliefs and approach-avoidance behaviors towards animals in typically developing children. *Behaviour Research and Therapy, 49*(1), 50-57.

Brown, T. A., Antony, M. M., & Barlow, D. H. (1992). Psychometric properties of the Penn State Worry Questionnaire in a clinical anxiety disorder sample. *Behaviour Research and Therapy, 30*, 33-37.

Brown, E. C., & Brüne, M. (2012). The role of prediction in social neuroscience. *Frontiers in Human Neuroscience*, 6(147), 1-19.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Newbury Park, CA: Sage.

Bruchey, A. K., Jones, C. E., & Monfils, M.-H. (2010). Fear conditioning by-proxy: Social transmission of fear during memory retrieval. *Behavioural Brain Research, In Press, Corrected Proof.*

Buer, N., & Linton, S. J. (2002). Fear-avoidance beliefs and catastrophizing: Occurence and risk factor in back pain and ADL in the general population. *Pain, 99*(3), 485-491.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: psychometric properties of the English version. *Behaviour Research and Therapy, 40*, 931-945.

Buitenhuis, J., Jaspers, J. P. C., & Fidler, V. (2006). Can kinesiophobia predict the duration of neck symptoms in acute whiplash? *Clinical Journal of Pain, 22*(3), 272-277.

Burnham, K. P., & Anderson, D. R. (1998). *Model selection and inference: a practical information-theoretic approach*. New York: Springer-Verlag.

Burns, J. W., Mullen, J. T., Higdon, L. J., Wei, J. M., & Lansky, D. (2000). Validity of the Pain Anxiety Symptoms Scale (PASS): prediction of physical capacity variables. *Pain, 84*, 247-252.

Bushnell, M. C., Duncan, G. H., Hofbauer, R. K., Ha, B., Chen, J.-I., & Carrier, B. (1999). *Pain perception: Is there a role for primary somatosensory cortex?* Paper presented at the The Neurobiology of Pain

Butler, G., & Matthews, A. (1983). Cognitive processes in anxiety. *Advances in Behavior Research and Therapy, 5*, 551-565.

Byrne, B. M. (2001). *Structural equation modelling with AMOS: Basic concepts, applications, and programming*. Mahwah, NJ: Lawrence Erlbaum.

Carleton, R. N., Collimore, K. C., & Asmundson, G. J. G. (2010). ''It's not just the judgements—It's that I don't know'': Intolerance of uncertainty as a predictor of social anxiety. *Journal of Anxiety Disorders, 24*, 189-195.

Carleton, R. N., Gosselin, P., & Asmundson, G. J. G. (2010). The Intolerance of Uncertainty Index: Replication with an English sample. *Psychological Assessment, 22*(2), 396-406.

Carleton, R. N., Mulvogue, M. K., Thibodeau, M. A., McCabe, R. E., Antony, M. M., & Asmundson, G. J. G. (2012). Increasingly certain about uncertainty: Intolerance of uncertainty across anxiety and depression. *Journal of Anxiety Disorders, 26*, 468-479.

Carleton, R. N., Norton, M. A. P. J., & Asmundson, G. J. G. (2007). Fearing the unknown: A short version of the Intolerance of Uncertainty Scale. *Journal of Anxiety Disorders, 21*, 105-117.

Carleton, R. N., Sharpe, D., & Asmundson, G. J. G. (2007). Anxiety sensitivity and intolerance of uncertainty: Requisites of the fundamental fears? *Behaviour Research and Therapy, 45*, 2307-2316.

Carroll, E. M. A., Conroy, L., & Jones, L. (2011). Facial affect processing in patients receiving opioid treatment in palliative care: Preferential processing of threat in pain catastrophizers. *Journal of Pain and Symptom Management, 41*(6), 975-985.

Chambers, C. T., Cassidy, K. L., McGrath, P. J., Gilbert, C. A., & Craig, K. D. (1996). *Child facial coding system. Revised manual*. Halifax, Nova Scotia: Dalhousie University.

Chen, C. Y., & Hong, R. Y. (2010). Intolerance of uncertainty moderates the relation between negative life events and anxiety. *Personality and Individual Differences, 49*, 49-53.

Chen, Q., Panksepp, J. B., & Lahvis, G. P. (2009). Empathy is moderated by genetic background in mice. *PLoS One, 4*, 4387.

Church, R. M. (1959). Emotional reactions of rats to the pain of others. *Journal of Comparative and Physiological Psychology, 52*, 132-134.

Colloca, L., & Benedetti, F. (2009). Placebo analgesia induced by social observational learning. *Pain, 144*(1-2), 28-34.

Cook, M., Mineka, S., Wolkenstein, B., & Laitsch, K. (1985). Observational conditioning of snake fear in unrelated rhesus monkeys. *Journal of Abnormal Psychology, 94*(4), 591-610.

Craig, K. D. (1986). Social modeling influences on pain In R. A. Sternbach (Ed.), *Chronic pain: Psychological factors in rehabilitation* (pp. 73-109). Baltimore: Williams and Wilkins.

Craig, K. D., & PrKachin, K. M. (1978). Social modeling influences on sensory decision theory and psychophysiological indexes of pain. *Journal of Personality and Social Psychology, 36*(8), 805-815.

Craig, K. D., & Weiss, S. M. (1971). Vicarious influences on pain-threshold determinations. *Journal of Personality and Social Psychology, 19*(1), 53-59.

Crombez, G., Eccleston, C., Baeyens, F., & Eelen, P. (1998). When somatic information threatens, catastrophic thinking enhances attentional interference. *Pain, 75*(2-3), 187-198.

Crombez, G., Eccleston, C., Van Damme, S., Vlaeyen, J. W. S., & Karoly, P. (2012). The fear avoidance model of chronic pain: The next generation. *Clinical Journal of Pain, 28*(6), 475-483.

Crombez, G., Vlaeyen, J. W. S., Heuts, P. H. T. G., & Lysens, R. (1999). Pain-related fear is more disabling than pain itself: Evidence on the role of pain-related fear in chronic low back pain disability. *Pain, 80*, 329-339.

Crombie, I. K., Croft, P. R., Linton, S. J., LeResche, L., & Von Korff, M. (Eds.). (1999). *Epidemiology of pain*. Seattle, WA: IASP Press.

Cudeck, R. B., & Browne, M. W. (1983). Cross-validation of covariance structures. *Multivariate Behavioral Research, 18*, 147-167.

Darlow, B., Fullen, B. M., Dean, S., Hurley, D. A., Baxter, G. D., & Dowell, A. (2012). The association between health care professional attitudes and beliefs and the attitudes and beliefs, clinical management, and outcomes of patients with low back pain: A systematic review. *The European Journal of Pain, 16*, 3-17.

Davey, G. C. L. (1992). An expectancy model of laboratory preparedness effects. *Journal of Experimental Psychology: General, 121*, 24-40.

Davey, G. C. L. (1993). A comparison of three worry questionnaires. *Behaviour Research and Therapy, 31*, 51-56.

Davey, G. C. L. (1995). Preparedness and phobias: Specific evolved associations or generalized expectancy bias. *Behavioral and Brain Sciences, 18*, 289-325.

Davey, G. C. L. (1997). A conditioning model of phobias. In G. C. L. Davey (Ed.), *Phobias: A handbook of theory, research, and treatment* (pp. 301-322). Chichester, England: Wiley.

Davey, G. C. L. (2002). 'Nonspecific' rather than 'nonassociative' pathways to phobias: a commentary on Poulton and Menzies. *Behaviour Research and Therapy, 40*, 151-158.

Davey, G. C. L., & Matchett, G. (1994). Unconditioned stimulus rehearsal and the retention and enhancement of differential fear conditioning: Effects of trait and state anxiety. *Journal of Abnormal Psychology, 103*, 708-718.

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Catalog of Selected Documents in Psychology, 10*, 85.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology, 44*(1), 113-126.

de Bruin, G. O., Rassin, E., van der Heiden, C., & Muris, P. (2006). Psychometric properties of a Dutch version of the Intolerance of Uncertainty Scale. *Netherlands Journal of Psychology, 62*, 91-97.

De Clercq, A., Verschuere, B., De Vlieger, P., & Crombez, G. (2006). Psychophysiological Analysis (PSPHA): A modular script-based program for analyzing psychophysiological data. *Behavior Research Methods, 38*(3), 504-510.

De Corte, K., Buysse, A., Verhofstadt, L. L., Roeyers, H., Ponnet, K., & Davis, M. H. (2007). Measuring empathic tendencies: Reliability and validity of the Dutch version of the interpersonal reactivity index. *Psychologica Belgica, 47*(4), 235-260.

De Gelder, B., Snyder, J., Greve, D., Gerard, G., & Hadjikhani, N. (2004). Fear fosters flight: a mechanism for fear contagion when perceiving emotion expressed by a whole body. *Proceedings of the National Academy of Sciences of the United States of America, 101*(47), 16701-16706.

De Houwer, J. (2003). A structural analysis of indirect measures of attitudes. In J. Musch & K. C. Klauer (Eds.), *The psychology of evaluation* (pp. 219-244): Erlbaum.

De Houwer, J. (2007). A conceptual and theoretical analysis of evaluative conditioning. *The Spanish journal of psychology, 10*(2), 230-241.

De Houwer, J. (2009). The propositional approach to associative learning as an alternative for association formation models. *Learning & Behavior, 37*(1), 1-20.

De Houwer, J. (2012). Evaluative conditioning. In N. R. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 1179-1181). NY: Springer.

De Houwer, J., & Barnes-Holmes, D. (2010). Reconciling radical behaviorism and cognitive learning research: A general framework for research on learning.

de Jong, J. R., Vlaeyen, J. W. S., Onghena, P., Cuypers, C., den Hollander, M., & Ruijgrok, J. (2005). Reduction of pain-related fear in complex regional pain syndrome type I: the application of graded exposure in vivo. *Pain, 116*(3), 264-275.

de Jong, J. R., Vlaeyen, J. W. S., Van Eijsden, M., Loo, C., & Onghena, P. (2012). Reduction of pain-related fear and increased function and participation in work-related upper extremity pain (WRUEP): Effects of exposure in vivo. *Pain, 153*, 2109-2118.

De Peuter, S., de Jong, J. R., Crombez, G., & Vlaeyen, J. W. S. (2009). The nature and treatment of pain-related fear in chronic musculoskeletal pain. *Journal of Cognitive Psychotherapy, 23*(1), 85-103.

Deacon, B., & Abramowitz, J. S. (2008). Is hypochondriasis related to obsessive-compulsive disorder, panic disorder, or both? An empirical evaluation. *Journal of Cognitive Psychotherapy, 22*(2), 115-127.

Delgado, M. R., Olsson, A., & Phelps, E. A. (2006). Extending animal models of fear conditioning to humans. *Biological Psychology, 73*, 39-48.

den Hollander, M., de Jong, J. R., Volders, S., Goossens, M. E. J. B., Smeets, R. J. E. M., & Vlaeyen, J. W. S. (2010). Fear reduction in patients with chronic pain: a learning theory perspective. *Expert Review of Neurotherapeutics, 10*(11), 1733-1745.

Descartes, R. (1664). *L'homme et un traité de la formation du foetus du mesme autheur*. Paris: C Angot.

Dirikx, T., Vansteenwegen, D., Eelen, P., & Hermans, D. (2009). Non-differential return of fear in humans after a reinstatement procedure. *Acta Psychologica, 130*(3), 175-182.

Dubi, K., Rapee, R. M., Emerton, J. L., & Schniering, C. A. (2008). Maternal modeling and the acquisition of fear and avoidance in toddlers: Influence of stimulus preparedness and child temperament. *Journal of Abnormal Child Psychology, 36*, 499-512.

Dugas, M. J., Buhr, K., & Ladouceur, R. (2004). The role of intolerance of uncertainty in etiology and maintenance. In R. G. Heimberg, C. L. Turk & D. S. Mennin (Eds.), *Generalized anxiety disorder: Advances in research and practice* (pp. 143-163). New York: Guilford.

Dugas, M. J., Freeston, M. H., & Ladouceur, R. (1997). Intolerance of uncertainty and problem orientation in worry. *Cognitive Therapy and Research*, 593-606.

Dugas, M. J., Freeston, M. H., Ladouceur, R., Rhéaume, J., Provencher, M., & Boisvert, J.-M. (1998). Worry themes in primary GAD, secondary GAD, and other anxiety disorders. *Journal of Anxiety Disorders, 12*, 253-261.

Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: A preliminary test of a conceptual model. *Behaviour Research and Therapy, 36*, 215-226.

Dugas, M. J., Gosselin, P., & Ladouceur, R. (2001). Intolerance of uncertainty and worry: Investigating specificity in a nonclinical sample. *Cognitive Therapy and Research, 25*, 551-558.

Dugas, M. J., & Ladouceur, R. (2000). Treatment of GAD: Targeting intolerance of uncertainty in two types of worry. *Behavior Modification, 24*, 635-657.

Dugas, M. J., Ladouceur, R., Léger, E., Freeston, M. H., Langlois, F., & Provencher, M. D. (2003). Group cognitive-behavioral therapy for generalized anxiety disorder: Treatment outcome and long-term follow-up. *Journal of Consulting and Clinical Psychology, 71*, 821-825.

Dugas, M. J., Marchand, A., & Ladouceur, R. (2005). Further validation of a cognitive-behavioral model of generalized anxiety disorder: diagnostic and symptom specificity. *Anxiety Disorders, 19*, 329-343.

Dugas, M. J., & Robichaud, M. (2007). *Cognitive-behavioral treatment for generalized anxiety disorder: From science to practice*. New York: Routledge.

Dugas, M. J., Schwartz, A., & Francis, K. (2004). Intolerance of uncertainty, worry, and depression. *Cognitive Therapy and Research, 28*(6), 835-842.

Eccleston, C., & Crombez, G. (1999). Pain demands attention: A cognitive-affective model of the interruptive function of pain. *Psychological Bulletin, 125*(3), 356-366.

Effting, M., & Kindt, M. (2007). Contextual control of human fear associations in a renewal paradigm. *Behaviour Research and Therapy, 45*, 2002-2018.

Egliston, K.-A., & Rapee, R. M. (2007). Inhibition of fear acquisition in toddlers following positive modelling by their mothers. *Behaviour Research and Therapy, 45*, 1871-1882.

Ehlers, A. (1991). Cognitive factors in panic attacks: Symptom probability and sensitivity. *Journal of Cognitive Psychotherapy, 5*, 157-173.

Ehring, T., & Watkins, E. R. (2008). Repetitive negative thinking as a transdiagnostic process. *International Journal of Cognitive Therapy, 1*, 192-205.

Ekman, P., & Rosenberg, E. L. (1997). *What the face reveales. Basic and applied studies of spontaneous expression using the Facial Action Coding System (FACS)*. New York, Oxford: Oxford University Press.

Elliott, A. M., Smith, B. H., Penny, K. I., Smith, W. C., & Chambers, W. A. (1999). The epidemiology of chronic pain in the community. *Lancet, 354*, 1248-1252.

Engel, G. L. (1977). The need for a new medical model: A challenge for biomedicine. *Science, 196*(4286), 129-136.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hillsdale: Lawrence Erlbaum Associates.

Feldner, M. T., & Hekmat, H. (2001). Perceived control over anxiety-related events as a predictor in a cold pressor task. *Journal of Behavior Therapy and Experimental Psychiatry, 32*, 191-202.

Ferguson, C. J. (2010). Blazing angels or resident evil? Can violent video games be a force for good? *Review of General Psychology, 14*, 68-81.

Ferini-Strambi, L. (2011). Sleep disorders in multiple sclerosis. *Handbook of Clinical Neurology, 99*, 1139-1146.

Field, A. (2006). Is conditioning a useful framework for understanding the development and treatment of phobias? *Clinical Psychology Review, 26*, 857-875.

Field, A., & Davey, G. C. L. (2001). Conditioning models of childhood anxiety. In W. K. Silverman & P. A. Treffers (Eds.), *Anxiety disorders in children and adolescents: Research, assessment and intervention* (pp. 187-211). Cambridge: Cambridge University Press.

Field, A. P., Argyris, N. G., & Knowles, K. A. (2001). Who's afraid of the big bad wolf: a prospective paradigm to test Rachman's indirect pathways in children. *Behaviour Research and Therapy, 39*, 1259-1276.

Field, A. P., & Lawson, J. (2003). Fear information and the development of fears during childhood: effects on implicit fear responses and behavioural avoidance. *Behaviour Research and Therapy, 41*, 1277-1293.

Field, A. P., & Storksen-Coulson, H. (2007). The interaction of pathways to fear in childhood anxiety: A preliminary study. *Behaviour Research and Therapy, 45*(12), 3051-3059.

Fitzgibbon, B. M., Giummarra, M. J., Georgiou-Karistianis, N., Enticott, P. G., & Bradshaw, J. L. (2010). Shared pain: From empathy to synaesthesia. *Neuroscience & Biobehavioral Reviews, 34*(4), 500-512.

Foa, E. B., Steketee, G., Turner, R. M., & Fischer, S. C. (1980). Effects of imaginal exposure to feared disasters in obsessive-compulsive checkers. *Behaviour Research and Therapy, 18*, 449-455.

Fonteyne, R., Vervliet, B., Hermans, D., Baeyens, F., & Vansteenwegen, D. (2009). Reducing chronic anxiety by making the threatening event predictable: An experimental approach. *Behaviour Research and Therapy, 47*(10), 830-839.

Fordyce, W. E., Shelton, J. L., & Dundore, D. E. (1982). The modification of avoidance learning pain behaviors. *Journal of Behavioral Medicine, 5*(4), 405-414.

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*, 791-802.

Fresco, D. M., Heimberg, R. G., Mennin, D. S., & Turk, C. L. (2002). Confirmatory factor analysis of the Penn State Worry Questionnaire. *Behaviour Research and Therapy, 40*(3), 313-323.

Fryling, M. J., Johnston, C., & Hayes, L. J. (2011). Understanding observational learning: An interbehavioral approach. *The analysis of verbal behavior, 27*, 191-203.

Gagliese, L., & Melzack, R. (1997). Chronic pain in elderly people. *Pain, 70*(1), 3-14.

Gallagher, N. G., South, S. C., & Oltmanns, T. F. (2003). Attentional coping style in obsessive-compulsive personality disorder: a test of the intolerance of uncertainty hypothesis. *Personality and Individual Differences, 34*, 41-57.

Gatchel, R. G., Peng, Y. B., Peters, M. L., Fuchs, P. N., & Turk, D. C. (2007). The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychological Bulletin, 133*(4), 581-624.

Gerull, F. C., & Rapee, R. M. (2002). Mother knows best: effects of maternal modelling on the acquisition of fear and avoidance behaviour in toddlers. *Behaviour Research and Therapy, 40*, 279-287.

Gheldof, E. L. M., Crombez, G., Van den Bussche, E., Vinck, J., Van Nieuwenhuyse, A., Moens, G., et al. (2010). Pain-related fear predicts disability, but not pain severity: a path analythic approach of the fear-avoidance model. *European Journal of Pain, 14*, 871-879.

Gibson, E. J., & Walk, R. D. (1960). The visual cliff. *Scientific American, 202*, 64-71.

Godinho, F., Magnin, M., Frot, M., Perchet, C., & Garcia-Larrea, L. (2006). Emotional modulation of pain: Is it the sensation or what do we recall? *Journal of Neuroscience, 26*, 11454-11461.

Goodman, J. E., & McGrath, P. J. (2003). Mothers' modeling influences children's pain during a cold pressor task. *Pain, 104*, 559-565.

Goodman, J. E., McGrath, P. J., & Forward, S. P. (1997). In T. S. Jensen (Ed.), *Proceedings of the VIIIth World Congress on Pain. Progress in pain research and management* (Vol. 3, pp. 673-682). Seattle, WA: IASP Press.

Goubert, L., Craig, K. D., Vervoort, T., Morley, S., Sullivan, M. J. L., Williams, A. C. d. C., et al. (2005). Facing others in pain: the effects of empathy. *Pain, 118*, 285-288.

Goubert, L., Crombez, G., & Van Damme, S. (2004). The role of neuroticism, pain catastrophizing and pain-related fear in vigilance to pain: a structural equations approach. *Pain, 107*, 234-241.

Goubert, L., Vlaeyen, J. W. S., Crombez, G., & Craig, K. D. (2011). Learning about pain from others: An observational learning account. *The Journal of Pain, 12*(2), 167-174.

Greco, V., & Roger, D. (2001). Coping with uncertainty: The construction and validation of a new measure *Personality and Individual Differences, 31*, 519-534.

Greer, R. D., Singer-Dudek, J., & Gautraux, G. (2006). Observational learning. *International Journal of Psychology, 41*(6), 486-499.

Grotle, M., Vøllestad, N. K., Veierød, M. B., & Brox, J. I. (2004). Fear-avoidance beliefs and distress in relation to disability in acute and chronic low back pain. *Pain, 112*, 343-352.

Haba-Rubio, J. (2005). Psychiatric aspects of organic sleep disorders. *Dialogues in Clinical Neuroscience, 7*, 335-346.

Hadjistavropoulos, T., & Craig, K. D. (Eds.). (2004). *Pain: Psychological perspectives*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Hadjistavropoulos, T., Craig, K. D., Duck, S., Cano, A., Goubert, L., Jackson, P. L., et al. (2011). A biopsychosocial formulation of pain communication.

Harstall, C., & Ospina, M. (2003). How prevalent is chronic pain? *Clinical Updates, 11*(2), 1-4.

Hasenbring, M. I., & Verbunt, J. A. (2008). Fear-avoidance and endurance-related responses to pain: New models of behavior and their consequences for clinical practice. *Clinical Journal of Pain, 26*(9), 747-753.

Hedayati, M., Dugas, M. J., Buhr, K., & Francis, K. (2003). *The relationship between intolerance of uncertainty and the interpretation of ambiguous and unambiguous information*. Paper presented at the Annual Convention of the Association for Advancement of Behaviour Therapy.

Helsen, K., Goubert, L., Peters, M. L., & Vlaeyen, J. W. S. (2011). Observational learning and pain-related fear: An experimental study with colored cold pressor tasks. *The Journal of Pain, 12*, 1230-1239.

Helsen, K., Leeuw, M., & Vlaeyen, J. W. S. (2013). Fear and pain. In R. F. Schmidt & W. D. Willis (Eds.), *Encyclopedia of pain, 2nd edition*: Springer-Verlag.

Helsen, K., Vlaeyen, J. W. S., & Goubert, L. (submitted). Indirect acquisition of pain-related fear: An experimental study of observational learning using coloured cold metal bars.

Hermann, C. (2007). Modeling, social learning in pain. In R. F. Schmidt & W. D. Willis (Eds.), *The Encyclopedia of Pain* (pp. 491-493). Heidelberg: Springer Publishing.

Hirsh, A. T., George, S. Z., Bialosky, J. E., & Robinson, M. E. (2008). Fear of pain, pain catastrophizing, and acute pain perception: Relative prediction and timing of assessment. *The Journal of Pain, 9*(9), 806-812.

Hoffman, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin, 136*, 390-421.

Holaway, R. M., Heimberg, R. G., & Coles, M. E. (2006). Acomparison of intolerance of uncertainty in analogue obsessive-compulsive disorder and generalized anxiety disorder. *Anxiety Disorders, 20*, 158-174.

Hollander, M., de Jong, J. R., Volders, S., Goossens, M. E. J. B., Smeets, R. J., & Vlaeyen, J. W. S. (2010). Fear reduction in patients with chronic pain: A learning theory perspective. *Expert Review of Neurotherapeutics, 10*(11), 1733-1745.

Horton, R. E., & Riddell, R. R. P. (2010). Mothers' facial expressions of pain and fear and infants' pain response during immunization. *Infant Mental Health Journal, 31*(4), 397-411.

Houben, R. M., Ostelo, R. W., Vlaeyen, J. W., Wolters, P. M., Peters, M. L., & Stomp-van den Berg, S. G. (2005). Health care providers' orientations towards common low back pain predict perceived harmfulness of physical activities and recommendations regarding return to normal activity. *European Journal of Pain, 9*(2), 173-183.

Hygge, S., & Öhman, A. (1978). Modeling processes in the acquisition of fears: Vicarious electrodermal conditioning to fear-relevant stimuli. *Journal of Personality and Social Psychology, 36*(3), 271-279.

Jensen, M. P., Turner, J. A., & Romano, J. M. (2001). Changes in beliefs, catastrophizing, and coping are associated with improvement in multidisciplinary pain treatment. *Journal of Consulting and Clinical Psychology, 69*(4), 655-662.

Jeon, D., Kim, S., Chetana, M., Jo, D., Ruley, H. E., Lin, S.-Y., et al. (2010). Observational fear learning involves affective pain system and Ca v 1.2 Ca2+ channels in ACC. *Nature Neuroscience, 13*(4), 482-490.

Jöreskog, K. G., & Sörbom, D. (1984). Lisrel IV User's Guide. Mooresville, IL.

Keefe, F. J., Caldwell, D. S., Baucom, D., Salley, A., Robinson, E., Timmons, K., et al. (1996). Spouse assisted coping skills training in the management of osteoarthritic knee pain. *Arthritis and Rheumatism, 9*(4), 279-291.

Keefer, L., Sanders, K., Sykes, M. A., Blanchard, E. B., Lackner, J. M., & Krasner, S. (2005). Towards a better understanding of anxiety in irritable bowel syndrome: A preliminary look at worry and intolerance of uncertainty. *Journal of Cognitive Psychotherapy, 19*(2), 163-172.

Kelly, M. M., & Forsyth, J. P. (2007a). Observational fear conditioning in the acquisition and extinction of attentional bias for threat: An experimental evaluation. *Emotion, 7*(2), 324-335.

Kelly, M. M., & Forsyth, J. P. (2007b). Sex differences in response to an observational fear conditioning procedure. *Behavior Therapy, 38*, 340-349.

Kent, G. (1997). Dental phobias. In G. C. L. Davey (Ed.), *Phobias: A handbook of theory, research and treatment* (pp. 107-127). Chichester, England: Wiley.

Keogh, E., Ellery, D., Hunt, C., & Hannent, I. (2001). Selective attentional bias for pain-related stimuli amongst pain fearful individuals. *Pain, 91*, 91-100.

King, N. J. (2005). Childhood fears and phobias: Advances in assessment and treatment. *Behaviour Change, 22*(4), 199-211.

King, N. J., Gullone, E., & Ollendick, T. H. (1998). Etiology of childhood phobias: current status of Rachman's three pathways theory. *Behaviour Research and Therapy, 36*, 297-309.

Kleinknecht, R. A. (2002). Comments on: Non-associative fear acquisition: A review of the evidence from retrospective and longitudinal research. *Behaviour Research and Therapy, 40*, 159-163.

Koch, M. D., O'Neill, H. K., Sawchuk, C. N., & Connolly, K. (2002). Domain-specific and generalized disgust sensitivity in blood-injection-injury phobia: The application of behavioral approach/avoidance tasks. *Journal of Anxiety Disorders, 16*(5), 511-527.

Koerner, N., & Dugas, M. J. (2008). An investigation of appraisals in individuals vulnerable to excessive worry: The role of intolerance of uncertainty. *Cognitive Therapy and Research, 32*, 619-638.

Konstantellou, A., Campbell, M., Eisler, I., Simic, M., & Treasure, J. (2011). Testing a cognitive model of generalized anxiety disorder in the eating disorders. *Journal of Anxiety Disorders, 25*, 864-869.

Kori, S. H., Miller, R. P., & Todd, D. D. (1990). Kinesiophobia: A new view of chronic pain behavior. *Pain Manage*, 35-43.

Koutantji, M., Pearce, S. A., & Oakley, D. A. (1998). The relationship between gender and family history of pain with current pain experience and awareness of pain in others. *Pain, 77*, 25-31.

Koyama, T., McHaffie, J. G., Laurienti, P. J., & Coghill, R. C. (2005). The subjective experience of pain: Where expectations become reality. *Proceedings of the National Academy of Sciences of the United States of America, 102*(36), 12950-12955.

Kronborg, C., Handberg, G., & Axelsen, F. (2008). Health care costs, work productivity and activity impairment in non-malignant chronic pain patients. *European Journal of Health Economics, 10*(1), 5-13.

Kugler, K., Wijn, J., Geilen, M., de Jong, J. R., & Vlaeyen, J. W. S. (1999). *The Photograph Series of Daily Activities (PHODA)*. Heerlen, The Netherlands: Institute for Rehabilitation Research and School for Physiotherapy.

Ladouceur, R., Dugas, M. J., Freeston, M. H., Léger, E., Gagnon, F., & Thibodeau, N. (2000). Efficacy of a new cognitive-behavioral treatment for generalized anxiety disorder: Evaluation in a controlled clinical trial. *Journal of Consulting and Clinical Psychology, 68*, 957-964.

Ladouceur, R., Dugas, M. J., Freeston, M. H., Rhéaume, J., Blais, F., Boisvert, J.-M., et al. (1999). Specificity of generalized anxiety disorder symptoms and processes. *Behavior Therapy, 30*(2), 191-207.

Ladouceur, R., Gosselin, F., & Dugas, M. J. (2000). Experimental manipulation of intolerance of uncertainty: A study of a theoretical model of worry. *Behaviour Research and Therapy, 38*, 933-941.

LaMotte, R. H., Lundberg, L. E. R., & Torebjörk, H. E. (1992). Pain, hyperalgesia and activity in nociceptive C units in humans after intradermal injection of Capsaicin. *Journal of Physiology, 448*, 749-764.

Lang, P. J. (1968). *Fear reduction and fear behavior: Problems in treating a construct* (Vol. 3). Washington DC: American Psychological Association.

Laugesen, N., Dugas, M. J., & Bukowski, W. M. (2003). Understanding adolescent worry: The application of a cognitive model. *Journal of Abnormal Child Psychology, 31*(1), 55-64.

Leeuw, M., Goossens, M. E. J. B., Linton, S. J., Crombez, G., Boersma, K., & Vlaeyen, J. W. S. (2007). The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. *Journal of Behavioral Medicine, 30*(1), 77-94.

Leeuw, M., Vlaeyen, J. W. S., de Jong, J. R., & Goossens, M. E. J. B. (2006). *Behandelprotocol exposure in vivo bij chronische lage rugpijn*. Amsterdam, The Netherlands: Boom.

Lethem, J., Slade, P. D., Troup, J. D. G., & Bentley, G. (1983). Outline of a Fear Avoidance Model of exaggerated pain perception. *Behaviour Research and Therapy, 21*(4), 401-408.

Linton, S. J., Buer, N., Vlaeyen, J. W. S., & Hellsing, A. L. (2000). Are fear-avoidance beliefs related to the inception of an episode of back pain? A prospective study. *Psychology and Health, 14*, 1051-1059.

Linton, S. J., Vlaeyen, J. W. S., & Ostelo, R. (2002). The back pain beliefs of health care providers: Are we fear-avoidant? *Journal of Occupational Rehabilitation, 12*(4), 223-232.

Lissek, S., Powers, A. S., MsClure, E. B., Phelps, E. A., Woldehawariat, G., Grillon, C., et al. (2005). Classical fear conditioning in the anxiety disorders: a meta-analysis. *Behaviour Research and Therapy, 43*, 1391-1424.

Litt, M. D. (1996). A model of pain and anxiety associated with acute stressors: Distress in dental procedures. *Behaviour Research and Therapy, 34*(5/6), 459-476.

Loeser, J. D. (1982). Concepts of pain. In J. Stanton-Hicks & R. Boaz (Eds.), *Chronic low back pain* (pp. 109-142). New York: Raven Press.

Lohnberg, J. A. (2007). A review of outcome studies on Cognitive Behavioral Therapy for reducing fear-avoidance beliefs among individuals with chronic pain. *Journal of Clinical Psychology in Medical Settings, 14*, 113-122.

Lovibond, P. F. (2011). Learning and anxiety: A cognitive perspective. In T. Schachtman & S. Reilly (Eds.), *Associative learning and conditioning: Human and animal applications*.

Lovibond, P. F., & Shanks, D. R. (2002). The role of awareness in Pavlovian conditioning: Empirical evidence and theoretical implications. *Journal of Experimental Psychology: Animal Behavior Processes, 28*(1), 3-26.

Lubow, R. E. (1998). Latent inhibition and behavior pathology: Prophylactic and other possible effects of stimulus preexposure. In W. O'Donohue (Ed.), *Learning and behavior therapy* (pp. 107-121). Needham Heights, MA: Allyn & Bacon.

Lundberg, M., Larsson, M., Östlund, H., & Styf, J. (2006). Kinesiophobia among patients with musculoskeletal pain in primary healthcare. *Journal of Rehabilitation Medicine, 38*, 37-43.

Mahoney, A. E. J., & McEvoy, P. M. (2012). Changes in intolerance of uncertainty during cognitive behavior group therapy for social phobia. *Journal of Behavior Therapy and Experimental Psychiatry, 43*, 849-854.

Mailhot, J.-P., Vachon-Presseau, E., Jackson, P. L., & Rainville, P. (2012). Dispositional empathy modulate vicarious effects of dynamic pain expressions on spinal nociception, facial responses and acute pain. *European Journal of Neuroscience, 35*, 271-278.

Marks, I. M. (1987). *Fears, phobias, and rituals*. New York: Oxford University Press.

Marsch, H. W., Balla, J. R., & McDonalds, R. P. (1988). Goodness of fit indexes in confirmatory factor analysis: the effect of sample size. *Psychological Bulletin, 103*, 391-410.

Mason, V. L. (2009). Psychological factors of pain perception, communication and responses to treatment. In R. White & K. Harding (Eds.), *Trauma and pain in wound care Volume II* (pp. 204-217). Aberdeen: Wounds UK.

Matchett, G., & Davey, G. C. L. (1991). A test of a disease-avoidance model of animal phobias. *Behaviour Research and Therapy, 29*, 91-94.

McAlpine, L., & McGrath, P. J. (1999). Chronic and recurrent pain in children. In A. R. Block, E. F. Kremer & E. Fernandez (Eds.), *Handbook of pain syndromes* (pp. 529-545). Mahwah, NJ: Lawrence Erlbaum Associates.

McCracken, L. M., & Turk, D. C. (2002). Behavioral and cognitive-behavioral treatment for chronic pain. *Spine, 27*(22), 2564-2573.

McCracken, L. M., Zayfert, C., & Gross, R. T. (1992). The Pain Anxiety Symptoms Scale: Development and validation of a scale to measure fear of pain. *Pain, 50*, 67-73.

McCracken, L. M., Zayfert, C., & Gross, R. T. (1993). The Pain Anxiety Symptoms Scale (PASS): A multidimensional Measure of Pain-Specific Anxiety Symptoms. *Behavior Therapist, 16*, 183-184.

McEvoy, P. M., & Mahoney, A. E. J. (2011). Achieving certainty about the structure of intolerance of uncertainty in a treatment-seeking sample with anxiety and depression. *Journal of Anxiety Disorders, 25*, 112-122.

McNeil, D. W., & Rainwater, A. J. (1998). Development of the Fear of Pain Questionnaire-III. *Journal of Behavioral Medicine, 21*(4), 389-410.

Melzack, R. (1973). *The puzzle of pain*. New York: Basic Books.

Melzack, R., & Casey, K. L. (1968). Sensory, motivational and central control determinants of chronic pain: A new conceptual model. In D. R. Kenshalo (Ed.), *The skin senses: Proceedings of the first International Symposium on the Skin Senses* (pp. 423-443). Tallahassee, Florida.

Melzack, R., & Wall, P. D. (1965). Pain mechanisms: A new theory. *Science, 150*(3699), 971-979.

Melzack, R., & Wall, P. D. (1996). *The challenge of pain* (2nd ed.). London: Penguin.

Menzies, R. G. (1996). The origins of specific phobias in a mixed clinical sample: Classificatory differences between two origins instruments. *Journal of Anxiety Disorders, 10*(5), 347-354.

Menzies, R. G., & Parker, L. (2001). The origins of height fear: an evaluation of neoconditioning explanations. *Behaviour Research and Therapy, 39*, 185-199.

Merckelbach, H., de Jong, P. J., Muris, P., & van den Hout, M. A. (1996). The etiology of specific phobias: A review. *Clinical Psychology Review, 16*(4), 337-361.

Merckelbach, H., & Muris, P. (2001). Specific phobias. In E. J. L. Griez, C. Faravelli, D. Nutt & D. Zohar (Eds.), *Anxiety disorders: An introduction to clinical management and research* (pp. 105-135). Chichester: John Wiley and Sons, Ltd.

Merckelbach, H., Muris, P., & Schouten, E. (1996). Pathways to fear in spider phobic children. *Behaviour Research and Therapy, 34*(11-12), 935-938.

Merskey, H., & Bogduk, N. (1994). *IASP Task force on taxonomy: Classification of chronic pain: Descriptions of chronic pain syndromes and definitions of pain terms* (2nd ed.). Seattle: WA: IASP Press.

Metzger, R. L., Miller, M. L., Cohen, M., Sofka, M., & Borkovec, T. D. (1990). Worry changes decision making: The effect of negative thoughts on cognitive processing. *Journal of Clinical Psychology, 46*(1), 78-88.

Meulders, A., Vansteenwegen, D., & Vlaeyen, J. W. S. (2011). The acquisition of fear of movement-related pain and associative learning: A novel pain-relevant human fear conditioning paradigm. *Pain, 152*(11), 2460-2469.

Meulders, A., & Vlaeyen, J. W. S. (2012). Reduction of fear of movement-related pain an pain-related anxiety: An associative learning approach using a voluntary movement paradigm. *Pain, 153*, 1504-1513.

Meulders, A., & Vlaeyen, J. W. S. (in press). The acquisition and generalization of cued and contextual pain-related fear: An experimental study using a voluntary movement paradigm. *Pain*.

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy, 28*(6), 487-495.

Mikael, S. F., & von Baeyer, C. L. (1990). Pain, somatic focus, and emotional adjustment in children of chronic headache sufferers and controls. *Social Science and Medicine, 31*(1), 51-59.

Miller, R. P., Kori, S. H., & Todd, D. D. (1991). Tampa Scale Unpublished Report.

Mineka, S., & Cook, M. (1993). Mechanisms involved in the observational conditioning of fear. *Journal of experimental psychology, 122*, 23-38.

Mineka, S., Davidson, M., Cook, M., & Keir, R. (1984). Observational conditioning of snake fear in rhesus monkeys. *Journal of Abnormal Psychology, 93*(4), 355-372.

Mineka, S., & Oehlberg, K. (2008). The relevance of recent developments in classical conditioning to understanding the etiology and maintenance of anxiety disorders. *Acta Psychologica, 127*(3), 567-580.

Mineka, S., & Öhman, A. (2002). Born to fear: Non-associative vs associative factors in the etiology of phobias. *Behaviour Research and Therapy, 40*, 173-184.

Mineka, S., & Öhman, A. (2002). Learning and unlearning fears: Preparedness, neural pathways, and patients.

Phobias and preparedness: The selective, automatic, and encapsulated nature of fear. *Society of Biological Psychiatry, 52*, 927-937.

Mineka, S., & Sutton, J. (2006). *Contemporary learning theory perspectives on the etiology of fears and phobias*. Washington DC: American Psychological Association.

Mineka, S., & Zinbarg, R. (1996). Conditioning and ethiological models of anxiety disorders. In D. A. Hope (Ed.), *Nebraska symposium on motivation: Perspectives on anxiety, panic, and fear: Current theory and research in motivation* (Vol. 43, pp. 135-210). Lincoln: University of Nebraska Press.

Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American psychologist, 61*(1), 10-26.

Mitchell, C. J., De Houwer, J., & Lovibond, P. F. (2009). The propositional nature of human associative learning. *Behavioral and Brain Sciences, 32*(2), 183-246.

Molina, S., & Borkovec, T. D. (1994). The Penn State Worry Questionnaire: psychometric properties and associated characteristics. In G. C. L. Davey & F. Tallis (Eds.), *Worrying. Perspectives on Theory, Assessment and Treatment*. New York: McGraw-Hill.

Moritz, A. R., & Henriques, F. C. (1947). Studies in thermal injury II: the relative importance of time and surface temperature in the causation of cutaneous burns. *The American Journal of Pathology, 23*(5), 695-720.

Morley, S., & Eccleston, C. (2004). The Object of Fear in Pain. In G. J. G. Asmundson, J. W. S. Vlaeyen & G. Crombez (Eds.), *Understanding and Treating Fear of Pain*. Oxford: Oxford University Press.

Mumme, D. L., Fernald, A., & Herrera, C. (1996). Infants' responses to facial and vocal emotional signals in a social referencing paradigm. *Child development, 67*, 3219-3237.

Muris, P., Bodden, D., Merckelbach, H., Ollendick, T. H., & King, N. (2003). Fear of the beast: a prospective study on the effects of negative information on childhood fear. *Behaviour Research and Therapy, 41*, 195-208.

Muris, P., & Field, A. (2010). The role of verbal threat information in the development of childhood fear. 'Beware of the Jabberwock!'. *Clinical Child and Family Psychology Review, 13*, 129-150.

Muris, P., Huijding, J., Mayer, B., van As, W., & van Alem, S. (2010). Reduction of verbally learned fear in children: A comparison between positive information, imagery, and a control condition. *Journal of Behavior Therapy and Experimental Psychiatry*.

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100*(4), 569-582.

Norton, P. J. (2005). A psychometric analysis of the Intolerance of uncertainty scale among four racial groups. *Journal of Anxiety Disorders, 19*, 699-707.

Ollendick, T. H., & King, N. J. (1991). Origins of childhood fears: An evaluation of Rachman's theory of fear acquisition. *Behaviour Research and Therapy, 29*(2), 117-123.

Olsson, A., Nearing, K. I., & Phelps, E. A. (2007). Learning fears by observing others: the neural systems of social fear. *Social Cognitive and Affective Neuroscience, 2*(1), 3-11.

Olsson, A., & Phelps, E. A. (2004). Learned fear of "unseen" faces after Pavlovian, Observational, and Instructed fear. *Psychological Science*(12), 822-828.

Olsson, A., & Phelps, E. A. (2007). Social learning of fear. *Nature Neuroscience, 10*(9), 1095-1102.

Osman, A., Breitenstein, J. L., Barrios, F. X., Guttierrez, P. M., & Kopper, B. A. (2002). The Fear of Pain Questionnaire-III: Further reliability and validity with non-clinical samples. *Journal of Behavioral Medicine, 25*, 155-173.

Ostelo, R. W., & Vlaeyen, J. W. S. (2008). Attitudes and beliefs of health care providers: extending the fear-avoidance model. *Pain, 135*(1-2), 3-4.

Otto, M. W., Leyro, T. M., Christian, K., Deveney, C. M., Reese, H., Pollack, M. H., et al. (2007). Prediction of 'fear' acquisition in healthy control participants in a De Novo fear-conditioning paradigm. *Behavior Modification, 31*(1), 32-51.

Pavlov, I. P., & Anrep, G. V. (1927). *Conditioned reflexes: An investigation of the physiological activity of the cerebral cortex.* London: Oxford University Press/ Humphrey Milford.

Peeters, F. P. M. L., Ponds, R. W. H. M., & Vermeeren, M. T. G. (1996). Affectiviteit en zelfbeoordeling van depressie en angst. *Tijdschrift voor Psychiatrie*(3), 240-248.

Perquin, C. W., Hazebroek-Kampschreur, A. A., Hunfeld, J. A., Bohnen, A. M., van Suijlekom-Smit, L. W., Passchier, J., et al. (2000). Pain in children and adolescents: A common experience. *Pain, 87*, 51-58.

Peters, M. L., Vlaeyen, J. W. S., & Weber, W. E. J. (2005). The joint contribution of physical pathology, pain-related fear and catastrophizing to chronic back pain disability. *Pain, 113*, 45-50.

Petersen, S., Brulin, C., & Bergstrom, E. (2006). Recurrent pain symptoms in young schoolchildren are often multiple. *Pain, 121*, 145-150.

Picavet, H. S. J., Vlaeyen, J. W. S., & Schouten, J. S. A. G. (2002). Pain catastrophizing and kinesiophobia: Predictors of chronic low back pain. *American Journal of Epidemiology, 156*(11), 1028-1034.

Platow, M. J., Grace, D. M., Wilson, N., Burton, D., & Wilson, A. (2008). Psychological group membership as outcomes of resource distributions. *European Journal of Social Psychology, 38*, 836-851.

Poulton, R., & Menzies, R. G. (2002). Non-associative fear acquisition: a review of the evidence from retrospective and longitudinal research. *Behaviour Research and Therapy, 40*, 127-149.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879-891.

Preston, S. D., & de Waal, F. B. M. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences, 25*, 1-72.

PrKachin, K. M. (1986). Pain behavior is not unitary. *Behavioral Brain Science, 9*, 754-755.

Pruimboom, L., & van Dam, A. C. (2007). Chronic pain: A non-use disease. *Medical Hypotheses, 68*(3), 506-511.

Quartana, P. J., Campbell, C. M., & Edwards, R. R. (2009). Pain catastrophizing: a critical review. *Expert Review of Neurotherapeutics, 9*(5), 745-758.

Rachman, S. (1977). The conditioning theory of fear-acquisition: A critical examination. *Behaviour Research and Therapy, 15*, 375-387.

Rachman, S. (1991). Neo-conditioning and the classical theory of fear acquisition. *Clinical Psychology Review, 11*(2), 155-173.

Rainville, P., Duncan, G. H., Price, D. D., Carrier, B., & Bushnell, M. C. (1997). Pain Affect Encoded in Human Anterior Cingulate But Not Somatosensory Cortex. *Science, 277*, 968-971.

Rescorla, R. A. (2004). Spontaneous recovery. *Learning and Memory, 11*, 501-509.

Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal Of Behavior Therapy And Experimental Psychiatry, 38*(2), 105-120.

Roelofs, J., McCracken, L. M., Peters, M. L., Crombez, G., van Breukelen, G., & Vlaeyen, J. W. S. (2004). Psychometric evaluation of the Pain Anxiety Symptoms Scale (PASS) in chronic pain patients. *Journal of Behavioral Medicine, 27*(2), 167-183.

Roelofs, J., Peters, M. L., Deutz, J., Spijker, C., & Vlaeyen, J. W. S. (2005). The Fear of Pain Questionnaire (FPQ): Further psychometric examination in a non-clinical sample. *Pain, 116*, 339-346.

Roelofs, J., Peters, M. L., & Vlaeyen, J. W. S. (2002). Selective attention for pain-related information in healthy individuals: The role of pain and fear. *European Journal of Pain, 6*, 331-339.

Roemer, L. (2001). Measures for anxiety and related constructs. In M. M. Antony, S. M. Orsillo & L. Roemer (Eds.), *Practitioner's guide to empirically-based measures of anxiety*. New York: Kluwer Academic/ Plenum.

Rosen, N. O., & Knäuper, B. (2009). A little uncertainty goes a long way: State and trait differences in uncertainty interact to increase information seeking but also increase worry. *Health Communication, 24*, 228-238.

Russell, M., & Davey, G. C. L. (1993). The relationship between life events measures and anxiety and its cognitive correlates. *Personality and Individual Differences, 14*, 317-322.

Satterthwaite, F. E. (1946). An approximate distribution of estimates of variance components. *Biometrics Bulletin, 2*(110-114).

Seminowicz, D. A., & Davis, K. D. (2006). Cortical responses to pain in healthy individuals depends on pain catastrophizing. *Pain, 120*, 297-306.

Sexton, K. A., & Dugas, M. J. (2009). Defining Distinct Negative Beliefs About Uncertainty: Validating the Factor Structure of the Intolerance of Uncertainty Scale. *Psychological assessment, 21*(2), 176-186.

Sica, C., Coradeschi, D., Sanavio, E., & Novara, C. (2004). A study of the psychometric properties of the Obsessive Beliefs Inventory and Interpretations of Intrusions Inventory on clinical Italian individuals. *Anxiety Disorders, 18*, 291-307.

Skinner, B. F. (1948). 'Superstition' in the pigeon. *Journal of Experimental Psychology, 38*, 168-172.

Smith, B. H., Elliott, A. M., Chambers, W. A., Smith, W. C., Hannaford, P. C., & Penny, K. (2001). The impact of chronic pain in the community. *Family Practice, 18*(3), 292-299.

Sperry-Clark, J. A., McNeil, D. W., & Ciano-Federoff, L. (1999). *Assessing chronic pain patients: The Fear of Pain Questionnaire-III* (Vol. 17). Sarasota, FL: Professional Resource Press.

Spielberger, C. D., Gorsuch, R. L., & Luschene, R. (1970). *Test manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spruyt, A., Clarysse, J., Vansteenwegen, D., Baeyens, F., & Hermans, D. (2010). Affect 4.0: A free software package for implementing psychological and psychophysiological experiments. *Experimental Psychology, 57*, 36-45.

SPSS Inc. Chicago, IL, USA.

Staats, P. S., Hekmat, H., & Staats, A. W. (1996). Psychological behaviorism theory of pain: A basis for unity. *Pain forum, 5*, 194-207.

Stavosky, J. M., & Borkovec, T. D. (1988). The phenomenon of worry: Theory, research, treatment and its implications for women. *Women and Therapy, 6*, 77-95.

Steketee, G., Frost, R. O., & Cohen, I. (1998). Beliefs in Obsessive-Compulsive Disorder. *Journal of Anxiety Disorders, 12*(6), 525-537.

Sternheim, L., Startup, H., & Schmidt, U. (2011). An experimental exploration of behavioral and cognitive-emotional aspects of intolerance of uncertainty in eating disorder patients. *Journal of Anxiety Disorders, 25*, 806-812.

Steward, A. M., Polak, E., Young, R., & Schultz, I. Z. (2012). Injured workers' construction of expectations of return to work with sub-acute back pain: The role of perceived uncertainty. *Journal of Occupational Rehabilitation, 22*(1), 1-14.

Sullivan, M. J. L., Bishop, S. R., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment, 7*, 524-532.

Sullivan, M. J. L., Thorn, B., Haythornthwaite, J. A., Keefe, F., Martin, M., Bradley, L. A., et al. (2001). Theoretical perspectives on the relation between catastrophizing and pain. *Clinical Journal of Pain, 17*, 52-64.

Swinkels-Meewisse, E. J. C. M., Swinkels, R. A. H. M., Verbeek, A. L. M., & Vlaeyen, J. W. S. (2003). Psychometric properties of the Tampa Scale forKinesiophobia and the Fear-avoidance Beliefs Questionnaire in acute low back pain. *Manual Therapy, 8*(1), 29-36.

Swinkels-Meewisse, I. E., Roelofs, J., Schouten, E. G., Verbeek, A. L., Oostendorp, R. A., & Vlaeyen, J. W. S. (2006). Fear of movement/(re)injury predicting chronic disabling low back pain: a prospective inception cohort study. *Spine, 31*, 658-664.

Tabbert, K., Merz, C. J., Klucken, T., Schweckendiek, J., Vaitl, D., Wolf, O. T., et al. (2011). Influence of contingency awareness on neural, electrodermal, and evaluative responses during fear conditioning. *Social Cognitive and Affective Neuroscience, 6*(4), 495-506.

Tallis, F., Davey, G. C. L., & Capuzzo, N. (1994). The phenomenology of non-pathological worry: A preliminary investigation. In G. C. L. Davey & F. Tallis (Eds.), *Worrying: Perspectives on Theory, assessment and treatment*. Chichester, England: John Wiley.

Tallis, F., Eysenck, M. W., & Mathews, A. (1991). Elevated evidence requirements in worry. *Personality and Individual Differences, 12*, 21-27.

Thastum, M., Zachariae, R., Bjerring, P., & Herlin, T. (1997). Cold pressor pain: Comparing responses of juvenile arthritis patients and their parents. *Scandinavian Journal of Rheumatology, 26*, 272-279.

Thorndike, E. L. (1927). The law of effect. *American Journal of Psychology, 39*, 212-222.

Tolin, D. F., Abramowitz, J. S., Brigidi, B. D., & Foa, E. B. (2003). Intolerance of uncertainty in obsessive-compulsive disorder. *Anxiety Disorders, 17*, 233-242.

Turk, D. C., & Okifuji, A. (2002). Psychological factors in chronic pain: Evolution and revolution. *Journal of Consulting and Clinical Psychology, 70*(3), 678-690.

Turk, D. C., & Wilson, H. D. (2010). Fear of Pain as a Prognostic Factor in Chronic Pain: Conceptual Models, Assessment, and Treatment Implications. *Current Pain and Headache Reports, 14*(2), 88-95.

Turkat, I. D., & Guise, B. J. (1983). The effects of vicarious experience and stimulus intensity on pain termination and work avoidance. *Behavioral Research and Therapy, 21*, 241-245.

Vachon-Presseau, E., Martel, M. O., Roy, M., Caron, E., Jackson, P. L., & rainville, P. (2011). The multilevel organization of vicarious pain responses: Effects of pain cues and empathy traits on spinal nociception and acute pain. *Pain, 152*(7), 1525-1531.

Valeriani, m., Betti, V., Le Pera, D., De Armas, L., Miliucci, R., Restuccia, D., et al. (2008). Seeing the pain of others while being in pain: A laser-evoked potentials study. *NeuroImage, 40*(3), 1419-1428.

Van Damme, S., Crombez, G., Bijttebier, P., Goubert, L., & Van Houdenhove, B. (2002). A confirmatory factor analysis of the Pain Catastrophizing Scale: invariant factor structure across clinical and non-clinical populations. *Pain, 96*, 319-324.

Van Damme, S., Crombez, G., Van Nieuwenborgh-De Wever, K., & Goubert, L. (2008). Is distraction less effective when pain is threatening? An experimental investigation with the cold pressor task. *European Journal of Pain, 12*, 60-67.

van den Hout, J. H. C., Vlaeyen, J. W. S., Houben, R. M. A., Soeters, A. P. M., & Peters, M. L. (2001). The effects of failure feedback and pain-related fear on pain report, pain tolerance, and pain avoidance in chronic low back pain patients. *Pain, 92*, 247-257.

Van der Does, A. J. W. (2002). *Handleiding bij de Nederlandse bewerking van de BDI-II (Manual of the Dutch version of the BDI-II)*. San Antonio, TX/ Lisse, The Netherlands: The Psychological Cooperation/ Swets Test Publishers.

Van der Ploeg, H. M. (1980). Validity of the Zelf-Beoordelings-Vragenlijst (a Dutch version of the Spielberger State-Trait Anxiety Inventory). *Nederlands Tijdschrift Voor de Psychologie En Haar Grensgebieden, 35*, 243-249.

Van der Ploeg, H. M. (1999). *Handleiding bij de Zelf-Beoordelings Vragenlijst, ZBV*. Lisse, the Netherlands: Swets & Zeitlinger.

van Rijsoort, S., Emmelkamp, P., & Vervaeke, G. (1999). The Penn state worry questionnaire and the worry domains questionnaire: Structure, reliability and validity. *Clinical psychology & psychotherapy, 6*(4), 297-307.

Vaughan, K. B., & Lanzetta, J. T. (1980). Vicarious instigation and conditioning of facial expressive and autonomic responses to a model's expressive display of pain. *Journal of Personality and Social Psychology, 38*, 909-923.

Verhoeven, K., Crombez, G., Eccleston, C., Van Ryckeghem, D. M. L., Morley, S., & Van Damme, S. (2010). The role of motivation in distracting attention away from pain: An experimental study. *Pain, 149*(2), 229-234.

Vlaeyen, J. W. S., & Crombez, G. (1999). Fear of movement/(re)injury, avoidance and pain disability in chronic low back pain patients. *Manual Therapy, 4*(4), 187-195.

Vlaeyen, J. W. S., de Jong, J. R., Geilen, M., Heuts, P. H. T. G., & van Breukelen, G. (2001). Graded exposure in vivo in the treatment of pain-related fear: A replicated single-case experimental design in four patients with chronic low back pain. *Behaviour Research and Therapy, 39*(2), 151-166.

Vlaeyen, J. W. S., de Jong, J. R., Leeuw, M., & Crombez, G. (2004). Fear reduction in chronic pain: graded exposure in vivo with behavioral experiments. In G. J. G. Asmundson, Norton, P.J., and Norton, G.R., J. W. S. Vlaeyen & G. Crombez (Eds.), *Understanding and treating fear of pain* (pp. 313-343). Oxford: Oxford University Press.

Vlaeyen, J. W. S., de Jong, J. R., Sieben, J., & Crombez, G. (2002). Graded exposure in vivo for pain-related fear. In D. C. Turk & R. J. Gatchel (Eds.), *Psychological approaches to pain management: A practioner's handbook* (2nd ed., pp. 210-233). New York: Guilford Press.

Vlaeyen, J. W. S., Hanssen, M., Goubert, L., Vervoort, T., Peters, M. L., Van Breukelen, G., et al. (2009). Threat of pain influences social context effects on verbal pain report and facial expression. *Behaviour Research and Therapy, 47*(9), 774-782.

Vlaeyen, J. W. S., Kole-Snijders, A. M. J., Boeren, R. G. B., & van Eek, H. (1995). Fear of movement/ (re)injury in chronic low back pain and its relation to behavioral performance. *Pain, 62*, 363-372.

Vlaeyen, J. W. S., & Linton, S. J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain. *Pain, 85*, 317-332.

Vlaeyen, J. W. S., & Linton, S. J. (2012). Fear-avoidance model of chronic musculoskeletal pain: 12 years on. *Pain, 153*, 1144-1147.

Vlaeyen, J. W. S., & Morley, S. (2004). Active despite pain: the putative role of stop-rules and current mood. *Pain, 110*(3), 512-516.

Vlaeyen, J. W. S., & Morley, S. (2009). Cognitive and behavioural factors in fibromyalgia: mood, goals, and task performance. *Journal of Musculoskeletal Pain, 17*, 295-301.

Vlaeyen, J. W. S., Morley, S., Linton, S. J., Boersma, K., & de Jong, J. R. (2012). *Pain-related fear: Exposure-based treatment for chronic pain*. Seattle: IASP Press.

Von Korff, M., Crane, P., Lane, M., Miglioretti, D. L., Simon, G., Saunders, K., et al. (2005). Chronic spinal pain and physical–mental comorbidity in the United States: results from the national comorbidity survey replication *Pain, 113*(3), 331-339.

Vrana, S. R., Spence, E. L., & Lang, P. J. (1988). The startle probe response: A new measure of emotion? *Journal of Abnormal Psychology, 97*(4), 487-491.

Waddell, G., Newton, M., Henderson, I., Somerville, D., & Main, C. J. (1993). A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain, 52*(2), 157-168.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS Scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology, 3*, 1-22.

White, K., & Davey, G. C. L. (1989). Sensory preconditioning and US inflation in human fear conditioning. *Behaviour Research and Therapy, 27*, 161-166.

Wideman, T. H., Adams, H., & Sullivan, M. J. L. (2009). A prospective sequential analysis of the fear-avoidance model of pain. *Pain, 145*, 45-51.

Williams, A. C. (2002). Facial expression of pain: An evolutionary account. *Behavioral and Brain Sciences, 25*(4), 439-488.

Woods, M. P., & Asmundson, G. J. G. (2008). Evaluating the efficacy of graded in vivo exposure for the treatment of fear in patients with chronic back pain: a randomized controlled clinical trial. *Pain, 136*, 271-280.

Wortman, C. B., & Loftus, E. F. (Eds.). (1992). *Psychology* (4th ed.). New York: McGraw-Hill.

Wunsch, A., Philippot, P., & Plaghki, L. (2003). Affective associative learning modifies the sensory perception of nociceptive stimuli without participant's awareness. *Pain, 102*(1-2), 27-38.

Yamada, M., & Decety, J. (2009). Unconscious affective processing and empathy. *Pain, 143*, 71-75.

Yook, K., Kim, K.-H., Suh, S. Y., & Lee, K. S. (2010). Intolerance of uncertainty, worry, and rumination in major depressive disorder and generalized anxiety disorder. *Journal of Anxiety Disorders, 24*, 623-628.